

THE
GRASSLANDS
OF
LATIN AMERICA

G. M. ROSEVEARE



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	Page
FOREWORD	4
CHAPTER 1. Introduction	9
CHAPTER 2. The natural grasslands. Type 1. Good natural grasslands	14
(a) The humid pampa of Argentina	16
(b) Uruguay	34
(c) The south of Brazil	50
(d) Entre Ríos	56
(e) The Magellan lands	62
(f) The Pre-Andean Depression	63
CHAPTER 3. Natural grazings in the Province of Corrientes, Argentina, and stock-raising in the Argentine Chaco. By L. R. PARODI	65
CHAPTER 4. The natural grasslands. Type 2. Cool mountain grasslands	70
(a) The Andean grazings of central Chile	73
(b) The Andean grazings of Peru and Ecuador	80
(c) The mountain grasslands of Colombia and Venezuela	86
(d) The mountain grazings of western Argentina and southern Chile	88
(e) The upland pastures of the central plateau, Costa Rica	90
(f) The páramos	90
CHAPTER 5. The natural grasslands. Type 3. Semi-arid grazings	93
(a) Central and northern Patagonia	99
(b) North-eastern Brazil	106
(c) The western dry pampa and the monte of Argentina	111
(d) Central Mexico... ..	114
(e) The campos of central Brazil, a transitional type	114
CHAPTER 6. The natural grasslands. Type 4. Savannahs of hot climates	117
(a) The Orinoco flood plains or Llanos of Venezuela and Colombia	126
(b) Bolívar savannahs of Colombia and the lowland savannahs of Costa Rica	129
(c) Savannahs of the Amazon Basin and of the Guianas	132
(d) The savannahs of Bolivia, Mato Grosso, and the Gran Chaco	135
(e) The Cuban savannahs... ..	136
CHAPTER 7. The temporary ley	164
CHAPTER 8. Browse plants, poisonous and undesirable plants	183
CHAPTER 9. Erosion, grassland and soil conservation	199
CHAPTER 10. Animal and plant health	211
CHAPTER 11. Management and improvement	224
CHAPTER 12. Botanical research	228
CHAPTER 13. Co-operation, research, and Government action	241
REFERENCES	272
INDEX OF AUTHORS	278
INDEX OF GENERA AND SPECIES	278

For seventeen years and more this Bureau has been collecting and indexing a great body of information on the provision of animal fodder under a wide range of conditions in all parts of the world. When a member of staff is given the job of summarizing a particular branch of this subject, it is soon found that the information available is extensive, scattered through a great many publications, and variable in scientific quality and accuracy. To present an objective review of such bodies of information is no mean task. The reviewer has to sift the literature and decide what facts, views and experiences deserve quoting; he or she has to present a cohesive story without attempting to influence the argument by statement of any personal views. The duty of a Bureau Officer is to present as far as possible an unbiassed picture and to leave the reader to weigh up one fact or viewpoint against another and make his own decisions.

This technique of handling information is still comparatively new to the agricultural reading public, which has not yet trained itself to absorb and analyse the mass of data which a Bureau can now place before it and formulate its own conclusions. The Bureau author is still expected to state his own viewpoint, and to make those easy generalizations which come extremely difficult to anyone working in the midst of the mass of collected information characteristic of any Bureau. The agricultural reviewer complains of too many data, with repeated statements of conflicting views on successive pages, and of the refusal of the author to commit himself. Having, however, set up the Imperial Agricultural Bureaux for the purpose of providing information, the research worker and adviser must now apparently accustom themselves to the use and digestion of that information, and the University professor should include in his lecture courses instructions to his students as to sources of information and how to use them.

Having abstracted and reviewed the literature from Latin America for many years, Miss Roseveare was asked to attempt to bring it under review in our publication. Any reader who expects a short, tidy account of a subject of such magnitude is expecting too much. Works from many journals and hundreds of books and occasional publications, originally written in several languages by authors of very varied scientific standing, and covering all manner of ecological and economic conditions of management and production, are here brought together for the first time. The author's task has not been an easy one; the fact that the reader must devote quite considerable study to the final synthesis is an indication of the size of the problem of managing grassland and producing animal fodder in a sub-continent with great potentialities but comparatively little as yet in the way of active research.

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MEASUREMENTS. These have as far as possible been expressed according to the metric system, rainfall in millimetres and temperatures according to Celsius, in agreement with the literature of Latin America. Where heights were originally in feet, rainfall in inches, land areas in acres, etc., these have been converted to the metric system, but not vice versa.

R. O. WHYTE.

MAPS

Fig.		Page
1	LATIN AMERICA	11
2	CLIMATIC REGIONS ACCORDING TO KÖPPEN'S CLASSIFICATION	12
3	CLIMATIC REGIONS ACCORDING TO THORNTHWAITE'S CLASSIFICATION	13
4	VEGETATION MAP OF SOUTH AMERICA. From the Oxford Advanced Atlas ...	15
5	THE SOILS OF SOUTH AMERICA. Map by F. Hardy	17
6	ARGENTINE REPUBLIC. PHYTOGEOGRAPHICAL REGIONS. Map by L. R. Parodi ...	23
7	NATURAL REGIONS OF ARGENTINA. Map by L. R. Parodi	25
8	ARGENTINA, showing the pampa, chief lucerne area, pampa of the Pergamino Region, southern limit of cattle ticks, and the western scrub or monte	26
9	URUGUAY	34
10	BRAZIL	50
11	PASTORAL REGIONS OF BRAZIL. After O. Domingues	52
12	PROVINCE OF ENTRE RÍOS, ARGENTINA. After J. R. Baez	57
13	PERU, CLIMATIC REGIONS AND AGRICULTURE. After H. Knuchel	74
14	ARID ZONE OF NORTH-EASTERN BRAZIL. After H. Noronha	101
15	WIND EROSION IN ARGENTINA. After Misc. Publ. No. 65 Min. Agric. Argentina. 1940	184

PLATES

Plate

- 1a ARGENTINA. The humid pampa. Flat plain 65 miles west south-west of Rosario. Vague, trail-like markings may be seen crossing the fields. (Photograph by J. L. Rich. 1942. Courtesy American Geographical Society)
- 1b ARGENTINA, PROVINCE OF ENTRE RÍOS. The plains of northern Entre Ríos, about 50 miles north of Concordia, showing the rich black soils and the numerous watercourses. (Photograph by J. L. Rich. 1942. Courtesy American Geographical Society) ...
- 2a NORTH-EASTERN URUGUAY. Unimproved area with *Erianthus trinitii* covering slopes and ridges. In the foreground, short sward continuously grazed while *E. trinitii* remains intact. *Baccharis trimera*, *B. coridifolia*, and *Eryngium paniculatum*, frequently associated with this type of grassland, are not shown. (Photograph by B. Rosengurt. 1938)
- 2b The same area as above, four years later, after cutting. (Photograph by B. Rosengurt. 1943)
- 3a NORTH-EASTERN URUGUAY. Unimproved tall grass area covered with *Erianthus trinitii*, with transition to short sward, centre right. (Photograph by B. Rosengurt. 1938)
- 3b The same as above, four years later, after cutting. Stock in the background entering for the first time. (Photograph by B. Rosengurt. 1943)
- 4a URUGUAY. Virgin grassland of the granite region. The sward is composed almost entirely of useful species: *Medicago hispida denticulata*, *Lolium multiflorum*, *Adesmia muricata*, *Rotiboealia selloana*, and a loose and grazed form of *Stipa charruana*. The worthless species are *Spilanthes decumbens*, *Hypochoeris* sp., and *Scutellaria racemosa*. *Festuca australis* and *Oxalis bipartita* are found in the interstices without being aggressive. (Photograph by B. Rosengurt. 1944)
- 4b NORTH-EASTERN URUGUAY. The normal sward of the Palleros grasslands in the Department of Cerro Largo. *Paspalum notatum* and *Axonopus compressus* are closely intermingled. Associated species are *Trifolium polymorphum*, *Piptochaetium panicoides* in loose and scattered tufts, *Oxalis macachin* and *Chaptalia exscapa*. (Photograph by B. Rosengurt. 1943)
- 5a ARGENTINA, PATAGONIA. Steppe in the valley on the China Muerta, central Neuquén. (Photograph by J. Frenguelli. 1941)
- 5b ARGENTINA, PATAGONIA. Steppe north of Las Heras, Santa Cruz. (Photograph by J. Frenguelli. 1941)
- 6a ARGENTINA. The dry pampa. Hard grasses and *Prosopis caldenia* in the Territory of La Pampa. (Photograph by J. Frenguelli. 1941)
- 6b ARGENTINA. The dry pampa. Transition from grassland to *Prosopis caldenia* "monte" or woodland, Territory of La Pampa. (Photograph by J. Frenguelli. 1941) ...

Plate

- 7 BRAZIL. Natural grasslands or " campos " used for cattle ranching, with fringe woodlands along the watercourses, 18 miles west of Guarapuava, State of Paraná. (Photograph by J. L. Rich. 1942. Courtesy American Geographical Society)
- 8a VENEZUELA. The Llanos. Palm savannah. (Photograph by H. Pittier)... ..
- 8b VENEZUELA. Mesa de Guanipa, in the Llanos. Savannah with the tree *Byrsonima crassifolia*. (Photograph by H. Pittier)
- 8c VENEZUELA. Woodland containing *Cereus*, Anzoátegui, in the Llanos. (Photograph by H. Pittier)... ..
- 9a VENEZUELA. Mesa de Guanipa, in the Llanos. Savannah, *Mauritia minor* in the background. (Photograph by H. Pittier)
- 9b VENEZUELA, Mesa de Guanipa, in the Llanos. Savannah, *Mauritia minor* and associated species in the background. (Photograph by H. Pittier)

TABLES

Table

										Page
1	Grasses and forage legumes of the humid pampa.	A. T. Semple...	...	...	...	...	...	...	...	29-30
2	Grasses and forage legumes, province of Buenos Aires.	A. T. Semple	...	...	...	...	...	...	...	31
3	Uruguayan grasslands. Dominant species in the sward.	Spangenberg, Nores, Montedónico and Fynn	...	...	...	...	...	...	...	38-45
4	Grasses of typical pastures, Entre Ríos and Corrientes.	A. T. Semple	...	...	...	...	...	...	...	61

CHAPTER 1

INTRODUCTION

"They landed. They brought with them some new animals looking very much like deer, but bigger, and they went about sitting on the backs of those animals, which made them very swift. I saw some of them overrun the whole plain in less time than it would take your best courier to run through my hall."

Papantzin in "The Heart of Jade", by Salvador de Madariaga, 1944, p. 264.

Papantzin, the Mexican princess, was describing the landing of Hernán Cortés with horses in 1519. The horses were followed by cattle and that not only in Mexico, but at several different points of the South American continent, and thus began the history of grassland utilization in Latin America. For the vast, apparently illimitable areas of natural grassland which so astonished the sixteenth century explorers and which had probably been in existence since prehistoric times, had been the happy grazing grounds of the rhea or ostrich and the guanaco or small llama, but were on the whole avoided by the pre-Columbian Indian inhabitants of the continent. The Indian civilizations had a high standard of agriculture in so far as crop production was concerned, with extremely well-developed irrigational systems and methods of storage, but they had no domestic animals apart from the dog, used in hunting, and in the Andean uplands the native llama and alpaca. Pastoral activities were totally unknown to them, and the lands subsequently used for this purpose were more or less uninhabitable for these agricultural peoples because the dense grass cover formed as serious an obstacle to cultivation as did forest growth.

The early European colonists were not slow to make use of the natural grazings, and the animals they introduced multiplied rapidly, at first in proximity to the colonial settlements, later running wild and ranging practically uncontrolled over vast tracts of land. At the same time the colonial period was one characterized mainly by a subsistence economy, there was no unduly heavy grazing of the grasslands, no serious destruction of forest in the mountains and no pumping of underground water.

The agriculture of the Indians preserved the natural resources intact; the pastoral activities of the colonists tended, if anything, to improve the conditions of their environment. With the coming of the modern period, however, coinciding in South America with the attainment of independent status by the various Portuguese and Spanish colonies, far-reaching changes began to take place.

In Latin America, as elsewhere in the world, the occupation of the humid grasslands was relatively scanty and they were comparatively little used before the middle of the nineteenth century. "The various techniques developed during the last century not only made possible the agricultural use of the grasslands, but also the connexion of these remote places with the city markets by much cheaper forms of transportation than had hitherto been available. Agricultural machinery for the first time in history made possible the cultivation of large areas from which the yield per acre was small; on the open grasslands barbed-wire fences made possible the separation of agricultural land from pastures, and also one pasture from another so that the breeding of animals could be controlled; well-drilling machines and cheap windmills made it possible to get water where water was difficult to find at the surface; and railroads and steamboats made it possible to ship the products of the farms to the expanding city markets." (James, 1941, p. 335.)

From the 1880's onwards a great expansion of the live-stock industry took place. In some parts, and notably in Argentina, it was little short of spectacular, and was stimulated by industrial expansion in Europe and therewith a demand for greater supplies of meat than were obtainable in

the Old World. The South American graziers seized their opportunity, but while the demands of the European market required and obtained improved technique in stock-breeding, little attention, on the whole, was paid to the requirements of the land, which received no fertilizer other than that supplied by the grazing animal. For a long time the amazingly fertile nature of many of the grazing lands bore this exploitation without exhibiting any marked deterioration, but within recent years there has been a considerable amount of uneasiness in the countries concerned as to the modifications in physical and plant resources which have taken and are taking place.

In other parts, again, the problem is concerned not with the over-use, but with an insufficient utilization of the existing natural resources, resulting in a periodic or even a constant shortage of meat and dairy products.

Most of the Latin American Governments and scientists are aware of the necessity of studying the problems that have arisen, and in many cases energetic and comprehensive measures are already being taken.

A new evaluation of indigenous resources and the realization that problems exist have led within the last two decades to the appearance of an increasing number of publications on the subject. In the present bulletin an attempt is made to review some of this literature.



FIG. 1. LATIN AMERICA. Map by M. E. EDWARDS



FIG. 2. CLIMATIC REGIONS ACCORDING TO KÖPPEN'S CLASSIFICATION

Map adapted by M. E. EDWARDS

Af : tropical rainforest climate; rainfall of the driest month is at least 2.4 in.

Aw : tropical savannah climate; distinct dry season in winter.

Bs : semiarid or steppe climate.

Bw : arid or desert climate.

Cw : warm temperate rainy climate; winter dry.

Cs : warm temperate rainy climate; Mediterranean type with summer drought.

Cf : humid temperate climate; no distinct dry season.

E : polar climate; average temperature of warmest month below 50° F.

F : perpetual frost.

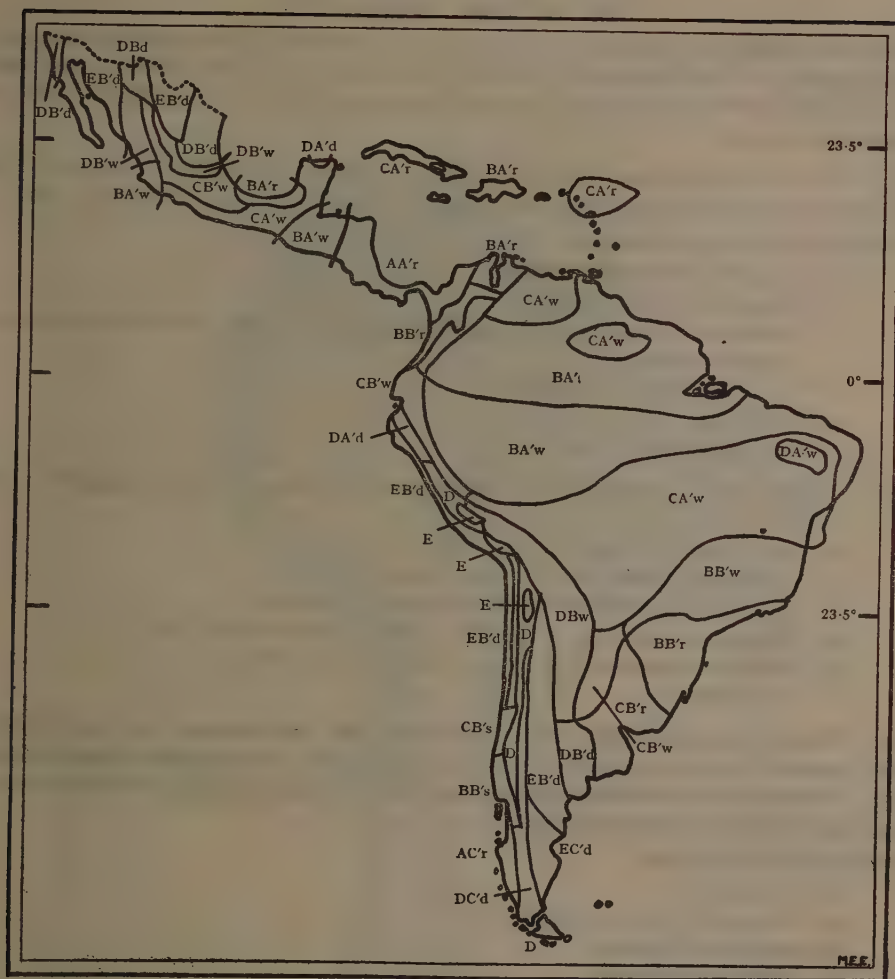


FIG. 3. CLIMATIC REGIONS ACCORDING TO THORNTON'S CLASSIFICATION

Map adapted by M. E. EDWARDS

AA'r : wet, tropical, rainfall abundant at all seasons.

AC'r : wet, microthermal, rainfall abundant at all seasons.

BA'r : humid, tropical, rainfall abundant at all seasons.

BA'w : humid, tropical rainfall scanty in winter.

BB'r : humid, mesothermal, rainfall abundant at all seasons.

BB'w : humid, mesothermal, rainfall scanty in winter.

BB's : humid, mesothermal, rainfall scanty in summer.

CA'r : subhumid, tropical, rainfall abundant at all seasons.

CA'w : subhumid, tropical, rainfall scanty in winter.

CB'r : subhumid, mesothermal, rainfall abundant at all seasons.

CB'w : subhumid, mesothermal, rainfall scanty in winter.

CB's : subhumid, mesothermal, rainfall scanty in summer.

DA'w : semiarid, tropical, rainfall scanty in winter.

DA'd : semiarid, tropical, rainfall scanty in all seasons.

DB'w : semiarid, mesothermal, rainfall scanty in winter.

DB'd : semiarid, mesothermal, rainfall scanty in all seasons.

DC'd : semiarid, microthermal, rainfall scanty in all seasons.

EB'd : arid, mesothermal, rainfall scanty in all seasons.

EC'd : arid, microthermal, rainfall scanty in all seasons.

D' : taiga.

E' : tundra.

CHAPTER 2

THE NATURAL GRASSLANDS

Surveys or partial surveys that have been made enable four broadly outlined types of grassland to be distinguished. The following list, while not attempting to classify all the natural grazings of Latin America, gives the four types in the approximate order of their agricultural value, with some examples of each.

Type 1. Good natural grasslands, wholly or mostly tick-free, having good herbage and a more or less temperate climate without extremes or regular seasons of excessive drought or rain.

Examples of these are found in :

- (a) The humid pampa of Argentina.
- (b) The greater part of Uruguay.
- (c) The south of Brazil, from the southern boundary of the State of São Paulo to the Uruguayan frontier.
- (d) Part of Entre Ríos, Argentina.
- (e) The Magellan lands.
- (f) The Pre-Andean Depression.

Type 2. Cool mountain grasslands, often usable only in summer. Some examples of these are :

- (a) The Andean grazings of central Chile.
- (b) The Andean grazings of Peru and Ecuador.
- (c) The mountain grasslands of Colombia and Venezuela.
- (d) The mountain grazings of western Argentina and southern Chile.
- (e) The upland pastures of the central plateau, Costa Rica.
- (f) The páramos.

Type 3. More or less arid grazings found in both hot and cold climates ; not very nutritious, suitable, however, for raising sheep and store cattle, all on the wide ranching or range system of grazing. These areas are often interspersed with shrubs, cacti, and trees mainly of the thorned type, but they are sometimes purely grass steppe.

Examples of Type 3 are :

In a cool climate :

- (a) The greater part of Patagonia.

In warm to hot climates :

- (b) North-eastern Brazil.
- (c) The western, dry pampa and the monte of Argentina.
- (d) Central Mexico.
- (e) Central Brazil (a transition type).

Type 4. Savannahs of hot climates, alternately excessively dry and excessively wet, liable to flooding and to tick and other pests. Creole (native) cattle, or hardy crosses with creole, alone seem able to resist the heat and pests.

Examples are found in :

- (a) The Orinoco flood plains or " Llanos " of Venezuela and Colombia.
- (b) The Bolivian savannahs of Colombia and the lowland savannahs of Costa Rica.
- (c) Savannahs of the Amazon basin and of the Guianas.
- (d) The savannahs of Bolivia, Mato Grosso and the Gran Chaco.
- (e) The Cuban savannahs.

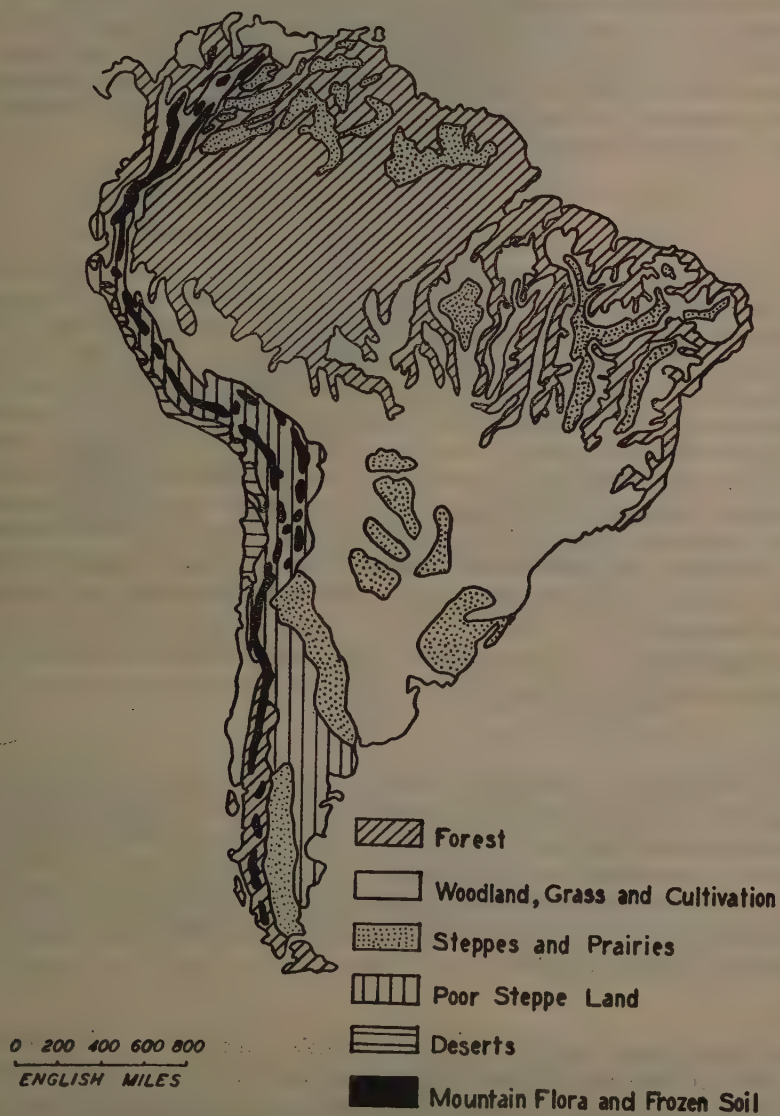


FIG. 4. VEGETATION MAP OF SOUTH AMERICA. *From The Oxford Advanced Atlas*

It is possible that the economic value of Type 3 may be greater than that of Type 2 on account of the relatively inaccessible nature of the latter. It is probable also that some of the areas included in Type 2 should more properly appear in Type 1. This applies especially to some Peruvian grasslands of the 2,500 to 3,500 metre level, but precise information on this point is lacking and the present inaccessibility of these lands certainly reduces their economic value.

There are doubtless many areas which are transitional between the different types of grassland listed above, and the list of examples does not claim to be by any means exhaustive. For example, there is little doubt that some of the grasslands of Ecuador and other countries should be included under Type 1. It is of interest, however, to note that many of the examples chosen represent if not the only, yet the principal agricultural resource and often the principal economic resource of the region concerned. In describing the different types, reference will be made to some other examples noted in the literature.

TYPE 1. GOOD NATURAL GRASSLANDS

(a) The humid pampa of Argentina

"The wide pampa rough with long grass; a vast level disc, the horizon encircling it with a ring as faultless as that made by a pebble dropped into smooth water" is the description by W. H. Hudson, himself born and bred on the pampa, in his tale "Niño Diablo". Waldo Frank (1944) writes: "Argentine's peculiarity is the pampa. Yes, I know: only half of Argentina is, literally, pampa. Patagonia, except in its northern reaches, is undulant waste; the west and north are mountain walls. But Argentina of the Argentines—of at least eighty per cent of its fourteen million people—lives on the pampa. From the sugar fields of Tucumán south to Santa Fe and the entire huge Province of Buenos Aires, the land is pampa. Mendoza, under the abrupt west wall of the Andes, is pampa; and all the middle provinces to the Atlantic. The mountains of Jujuy and Salta terminate in pampa. The huge north rivers, as they move south, become pampas of water. Pampa and the earth-bearing Río de la Plata are related. Even the infernoesque chill lands of the south move northward, as the great north rivers southward, pampa-bound and eventually pampa.

And what is pampa? It is flat land: not approximately flat like the prairies, like the steppes and llanos, but land absolutely geodesically flat like the surface of a globe in a schoolroom."

DEFINITION

The word pampa is Quechuan and denotes a plain. The Argentine pampas constitute one of the four major physical divisions of the country, and comprise the great plains which lie south of the Chaco and east of the Andean foothills. Two divisions are generally recognized, the wetter, eastern part, known as the humid pampa, and a drier, western part, called the dry pampa. Herein it is necessary to avoid confusion with the political division or Territory of La Pampa (Gobernación de La Pampa), the greater part of which belongs to the dry pampa, only the north-eastern corner falling within the humid pampa.

EXTENT

The humid pampa includes practically the whole of the province of Buenos Aires and parts of Santa Fe, Córdoba and La Pampa (*see* Figs. 6, 7, and 8).

Some authors include the southern part of Entre Ríos. It measures roughly 400,000 sq. km., including the steppe of Entre Ríos, 500,000 sq. km. (Parodi, 1945c.). McCullough (1944) gives the area as 93 million acres.

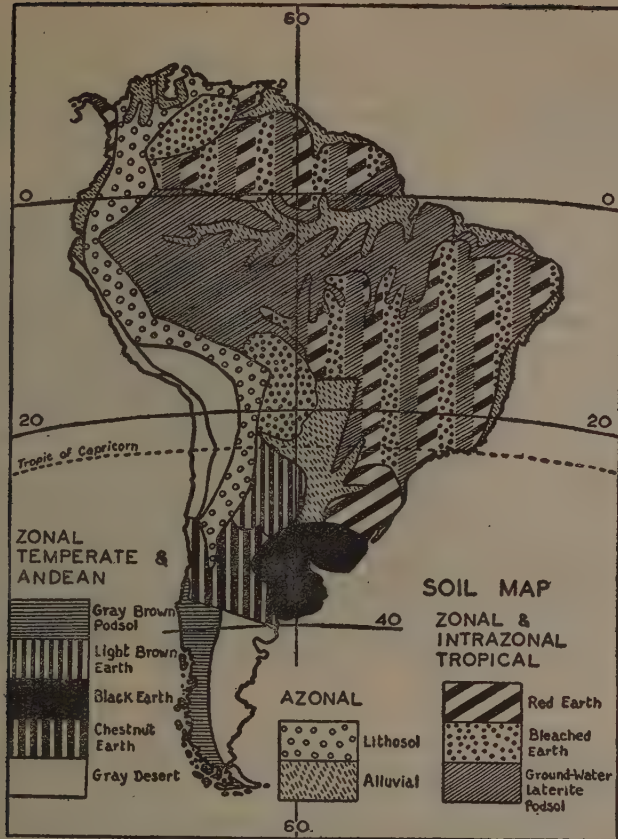


FIG. 5. THE SOILS OF SOUTH AMERICA. Map by F. HARDY. *Chron. bot.* 7. 213. 1942

SOILS

The soils have not as yet been mapped (James, 1941, p. 330). James writes: "The Argentine plains are actually composed of a deep accumulation of loose material resting on top of a hilly surface of granite and other ancient crystalline rock" and notes that much of this material is carried by the violent wind from the south-west known as the "pampero", picked up in the arid west and dropped in the more humid east. "Most of the humid pampa is so deeply mantled with unconsolidated beds of fine sand, clay, silt, and wind-blown dust, or loess, that the underlying rock is entirely obscured. Quite unlike Patagonia the soil of the humid pampa is entirely free of stones and pebbles. Here is a country where gravel is unknown." (James, 1941.) F. Hardy's soil map of South America (1942) shows the area of the humid pampa to be that of the fertile Black Earth soil, and McCullough states that it contains "some of the richest soil in the world" (1944). (See Fig. 5.)

CLIMATE

The climate of the greater part of the humid pampa is one of hot summers and mild winters, according to Köppen (1923) a typical *Cfa* climate. In the south-east of the province of Buenos Aires there is a region having the *Cfb* climate with cooler summers (warmest month below 22° C). (Schmieder, 1927.) (Fig. 2.)

ABSENCE OF TREES

A salient characteristic of the humid pampa in its natural condition is the almost entire absence of trees. Opinions differ as to the reason for this. The climate is that designated by Köppen as *Cf*, of which he says: "it produces luxuriant forests of high trees, wherever tree growth is not restricted by excessive winds or adverse soil condition". (Köppen, 1923; quoted by Schmieder, 1927.) And it is certainly true that wherever trees are cultivated, and this is practically always done in the vicinity of the estancia buildings and other dwellings, they thrive. The *ombú* (*Phytolacca dioica*), a native tree, was popular for this purpose with the early settlers of the pampa; more recently eucalypts and poplars, both introduced trees, have been more commonly grown. The peach, likewise introduced, also thrives well under cultivation on the pampa. The lack of natural tree growth has been variously attributed to the distribution of the underground water, to the frequent and strong winds that sweep the pampa, and to the presence of a "grass-land climate". (F. Kurtz, 1904; C. Darwin and A. Grisebach; H. Seckt, 1918; all quoted in Schmieder, 1927.) Schmieder (1927) considers that earlier scrub forest had been destroyed by pre-Columbian Indians having fired it, the scrub being replaced by the treeless grass pampa which made such a deep impression on the first Europeans who explored this country. Schmieder's view is not, however, supported by Parodi, the Argentine botanist and ecologist, who regards the pampean grasslands not as an induced but as a climax steppe, perpetuated with the climate but determined by the structure of the soil. The successful growth of planted trees is due, he writes, to careful cultivation, watering, etc., when they are young, and he points out that, even after a hundred and fifty years of tree cultivation, not a single species has become naturalized or seeded itself in the natural pampa. The soil is too compact and insufficiently aerated for trees to root in it and to reach the moist lower strata. (L. R. Parodi, 1942c.)

PLANT COVER

A change has taken place in the plant cover of the humid pampa since European eyes first beheld it in the early part of the sixteenth century. At that time the Spaniards found an endless panorama of tall, plumed bunchgrasses or of coarse rushes in the marshy spots, the only animals grazing the region being the guanaco (a type of llama), and the rhea or ostrich. The introduction of cattle by the colonists initiated a process of alteration, the result of which has not, however, been the same in all parts of the pampa. In the moister regions the grazing of cattle, and especially of sheep, destroyed the taller elements of the vegetation and produced a lawn-like, low, dense sod. (Azara, 1847, quoted by Schmieder, 1927.) In the more arid west, however, the continual grazing of cattle appears to have kept down or even destroyed the more tender grasses growing among the tall, hard grasses, thus promoting the predominance of the latter. This different reaction under grazing is not attributable alone to the greater humidity of the east and the more arid nature of the west, but also to other factors such as the heavier stocking of the east near the centres of colonization, and to the invasion of the eastern pampa by numerous European plants, many of them, no doubt, introduced incidentally. Some of the introduced plants were weeds, notably thistle species. *Cynara cardunculus*, the wild artichoke, is supposed to have been brought into the La Plata area in 1769, lodged in the coat of a donkey from Spain (Schmieder, 1927), and the position it had established for itself by the mid-nineteenth century, together with the giant thistle, *Silybum marianum*, may be judged by the following description of W. H. Hudson's.

"In places the land as far as one could see was covered with a dense growth of cardoon thistles, or wild artichoke, of a bluish or grey-green colour, while in other places the giant thistle flourished, a plant with big variegated green and white leaves, and standing when in flower six to ten feet high." (Hudson, 1918.) Of the giant thistle and its place in the agricultural economy of

the pampa the same author writes: "The aspect of the plain was different in what was called a 'thistle year', when the giant thistles, which usually occupied definite areas or grew in isolated patches, suddenly sprang up everywhere, and for a season covered most of the land. In these luxuriant years the plants grew as thick as sedges and bulrushes in their beds, and were taller than usual, attaining a height of about ten feet. . . . By the end of November the thistles would be dead, and their huge hollow stalks as dry and light as the shaft of a bird's feather—a feather-shaft twice as big round as a broomstick and six to eight feet long. . . . The thistle dead was just as great a nuisance as the thistle living, and in this dead dry condition they would sometimes stand all through December and January when the days were hottest and the danger of fire was ever present to people's minds. . . . After all this abuse of the giant thistle, it may sound odd to say that a 'thistle year' was a blessing in some ways. It was an anxious year on account of the fear of fire, . . . but a thistle year was called a fat year, since the animals—cattle, horses, sheep, and even pigs—browsed freely on the huge leaves and soft, sweetish-tasting stems, and were in excellent condition. The only drawbacks were that the riding-horses lost strength as they gained in fat, and cow's milk didn't taste nice." (W. H. Hudson, 1918.)

The introduced grasses, however, all contributed towards the improvement of the pampean grazings. They comprised the genera *Bromus* (*B. hordeaceus*), *Poa*, *Lolium*, *Avena*, *Hordeum*, *Briza* (*B. minor*), *Cynodon*, *Koeleria* (*K. phleoides*), and together with the herbs *Erodium cicutarium* and *Echium plantagineum*, legume species such as *Trifolium repens* and *Medicago denticulata*, with the poison hemlock (*Conium maculatum*) and the fennel (*Foeniculum vulgare*) and other plants, constituted the "tender herbage" that is distinguished from and valued far above the "hard herbage" of the native grasses. (Berg, 1877, quoted by Schmieder, 1927.)

TENDER, STRONG, AND HARD GRASSES

Throughout the literature on South American grasslands allusions to "tender", "strong", and "hard grasses" are continually met. These terms have a relative value, of which Parodi has given the following account.

"Three classes of grasses are distinguished in accordance with consistency, namely, tender, strong, and hard grasses.

"Tender or soft grasses. They are generally annuals, but there are also biennials and perennials; they have flat, narrow, flaccid, succulent leaves with very little sclerenchyma. They grow in very fertile, moist soils, or in tilled land. Examples are: *Poa annua*, *P. pratensis*, *Digitaria sanguinalis*, *Echinochloa colona*, *Paspalum dilatatum*, *P. distichum*, *Bromus mollis*, *B. catharticus*, *Lolium perenne*, etc. The term also includes dicotyledons such as *Trifolium repens*, *Medicago sativa*, *Erodium* sp., *Geranium* sp., etc.

"Strong grasses. In consistency they are intermediate between the tender and hard grasses. In general they are perennial grasses, strongly rooted, ordinarily caespitose, with narrow, flat or subconvolute leaves, more or less sclerenchymatous, adapted to intermediate ecological conditions, neither very moist nor very dry, such as are found in a large part of the pampean steppe. Examples are: *Stipa neesiana*, *S. hyalina*, *Tridens brasiliensis*, *Briza subaristata*, *B. stricta*, *Piptochaetium* sp., *Paspalum quadrifarium*, etc.

"Hard grasses. They usually have filiform, convolute leaves, very sclerenchymatous and siliceous, sometimes spiked; examples are *Stipa trichotoma*, *S. ichu*, *Festuca orthophylla*, etc. They are mediocre or poor grasses which can be very useful for goats or, in certain cases, for horned cattle when other herbage fails." (Parodi, 1946.)

Of the native grasses Parodi has stated: "It is surprising that as the pampa is a grass plain *par excellence* with more than 300 indigenous species of grasses, it has contributed to world agriculture only two species of secondary importance, *Bromus catharticus** and *Paspalum dilatatum*, and a decorative species, *Cortaderia dioica*, distributed to-day in parks and gardens throughout the world." (L. R. Parodi, 1935; quoted by Nyhus, 1940.) This was the position up to the end of the colonial period.

GROWTH OF ANIMAL INDUSTRY

Throughout the whole of the colonial period, that is to say, from the advent of the Spaniards in 1535 to the War of Independence in 1810, the cattle industry was of an almost entirely haphazard nature. Horses and cattle brought by the early settlers had escaped and multiplied, and roamed in a completely wild state in the almost illimitable, unfenced pastures of the pampa. The nomadic Indians of the country extended their activities from the hunting of the guanaco and ostrich to the hunting of cattle which they traded with Chile, and among the Europeans the presence of the cattle and horses living in a feral condition evolved the classic figure of the gaucho or cowboy of the pampa. "He lived in a land still without fences, without codified laws, and without economic problems. The cattle and horses imported from Spain had multiplied by the million; he took what he needed." (Waldo Frank, 1944.) Cattle and horse hides were the leading article of trade, later tallow and jerked (salted and dried) beef were added to the exports, both legal and contraband. The quality of the animals for this trade was not necessarily good, and little importance, consequently, was attached to the quality of the grazings; the cattle thrived equally well in one place as in another.

From the successful termination in 1810 of Argentina's revolution against the mother country, however, the position changed, for the newly-won ability to trade freely with other countries beside Spain gave an impetus to live-stock raising in the Rio Plata region, and after the expulsion of the dictator Rosas and the formation of a federal constitution in 1853, the development of the industry was very rapid. The system of large land holdings or *estancias* which still prevails had already come into existence in the colonial period. "An *estancia* may vary in size from a few thousand acres up to about 100,000 acres [40,469 hectares]. For example, there are about fifty families in the province of Buenos Aires who own over 75,000 acres [30,282 hectares] each. Actually an *estanciero* refers to his property as having so many leagues, a league being 2,500 hectares or 5,175 acres." (McCullough, 1944.) The building of railroads from 1857 onwards in a country where road-building, owing to the softness of the ground, was very difficult, opened up vast new trade possibilities to the landowner; the number of land holdings increased, fencing of the grazings with wire was introduced, the incursions of predatory Indians were suppressed and the Indians were pushed back westwards, the wild dog—the herd's worst enemy at that time—was exterminated, and the stray cattle were gradually rounded up and more or less domesticated. With the invention of the Tellier system of refrigeration in 1872 new European markets for Argentine beef opened up, but the scrub cattle adequate for the hide, tallow, and jerked beef trade were no longer sufficiently good for European consumption, and efforts to improve the native cattle by breeding—which had begun as early as 1840 with the introduction of the first pure-bred Shorthorn bull—were made, although they did not become general until after 1890 or 1900, when incentives were greater and the improvement in the Argentine cattle was so general and rapid "that it would be difficult to parallel the accomplishment in any other country". (Nyhus, 1940.) By 1938 Argentina shipped 80 per cent of all the meat exported from Latin America and 50 per cent of all the hides and skins. (James, 1941.)

*=*B. unioloides*. The name *B. catharticus* is used throughout this bulletin.

INTRODUCTION OF LUCERNE

Parallel with the development of the cattle industry a transformation in the use and plant cover of the pampa has taken place. Even the improved, tender herbage of the moister eastern grazings was insufficient for the adequate nutrition of the better class of stock now raised, and progressive landowners realized the necessity for interpolating a cultivated feed crop. Lucerne (*Medicago sativa*) was the answer to their problem, and from 1890 onwards lucerne has been the characteristic plant of the best pampa grazings. It was not new to Argentina, having already been introduced in the eighteenth century during the Spanish colonial days, when it came by the trade routes over the Andean cordilleras into the western Argentine province of Mendoza. (Boerger, 1938a.) "The rapid development of the present lucerne zone, however, actually belongs to the last fifty years. The region comprises principally the west of the province of Buenos Aires and bordering parts of the territory of La Pampa. The soil is light, often directly sand soil, having, however, a permeable subsoil in which the deep-rooting lucerne is able to find abundant supplies both of water and of lime (loess concretions). Noteworthy is the fact that the lucerne in these areas serves first and foremost for grazing, so that in the course of time a pasture type of lucerne, adapted to these circumstances, has been formed through the repeated grazing and treading of the animals." (Boerger, 1938a.) This last assertion, however, is called in question by some who have been testing Argentine lucernes elsewhere. (Davies, 1946.)

The introduction of lucerne resulted in a transformation not only of the grasslands of the pampa, but ultimately of its whole agricultural economy. Lucerne had to be grown in ploughed land, and many more workers were required than in the earlier days when the scrub animal was the sole source of income. Hence from 1856 onwards arose the large-scale introduction of agricultural immigrants into Argentina, mostly from Europe, and the formation of the peculiar Argentine tenant-farmer system. The landowner, being primarily interested in the raising and breeding of live stock, was only prepared to encourage cultivation—which he and his ordinary workers were neither numerous enough nor willing to do—for the purpose of obtaining adequate feed for his animals, and he found the best way to accomplish this was to let a part of his land for a period of four to five years to tenants and to allow them, for a share of the crop, to grow wheat or some other crop. After a certain period the land was then planted to lucerne and the tenant farmer, under his terms of contract, was obliged to move away. The lucerne ley furnished first-class grazing for a period of five years, on an average, and then reverted to grass. By this system, continued up to the present day in a modified form, the landowner not only increased his lucerne acreage but also derived considerable profit from a share of the crops. "Between 1853 and 1914 the great transformation of the Argentine humid pampa was accomplished. As more and more immigrants entered the country, the value of agricultural production mounted until at last the crops brought larger returns than the animals. In 1894 the three chief pastoral products together (wool, meat and hides) made up 63 per cent of the total value of exports; but in 1903, for the first time, the value of the combined agricultural products (maize, wheat, and linseed) exceeded the value of the animal products. The immigrant farmers supplied the necessary labour to reshape the economic destiny of the region; but the Argentine landowners were the ones who profited most from the spectacular increase of land values." (James, 1941, p. 345.)

Although the live-stock industry thus played a part in introducing grain farming into many tracts, soon after the construction of railways grain farming became established on a competitive and permanent basis. Nevertheless, in only a small part of the cereal zone has crop competition reduced the pasture acreage to less than half of the land area (Nyhus, 1940), and stock raising still remains the primary interest of most Argentine landowners (McCullough, 1944). "The fact is that

the steady basis of the rural economy of the alfalfa-wheat district is still pastoral, with alfalfa as the leading feed crop." (James, 1941, p. 350.)

William Davies, from observations made in the La Plata basin in 1938, traces the development of an Argentine lucerne ley from sowing to the end of the fifth harvest year, by which time the lucerne has largely disappeared and the ley has reverted to perennial grasses and weeds, although in the first, second, and sometimes in the third harvest year the lucerne is completely dominant to the virtual exclusion of all the annuals. (Davies, 1940.)

While *Medicago sativa* holds pride of place in leys cultivated for animal feed, the annuals *M. hispida*, *M. minima*, *M. arabica* and *M. lupulina* have also spread over a large part of the pampa region, where they have been grown for winter forage. The same is said of *Melilotus indica*. *Trifolium repens* is the most widely distributed clover in Argentina, *T. pratense* and *T. hybridum* have hardly been cultivated at all. (Burkart, 1943a.)

In relation to the area of rich lands available in the humid pampa the proportion occupied by lucerne is relatively small, and here there remains great scope for development. (Davies, 1940.) (Fig. 8.) The lucerne area reached a peak in 1918-19 of 8,703,270 hectares, but from 1929 onwards the figure has not exceeded five and a half million hectares, a decline attributed variously to erosion (Davies, 1940) and to economic causes (Boerger, 1938a). "But even so", writes Boerger, "the cultivation of lucerne in Argentina represents a particularly remarkable form of grassland farming, both on account of its widely extended area, still great even to-day, and also on account of the form of its utilization, namely, grazing" (Boerger, *loc. cit.*). Argentina still cultivates more lucerne than any other country in the world (Burkart, 1943a) and the lucerne zone is still the most important area for fattening cattle.*

THE NATURAL GRASSLAND

The normal grassland of the present pampa varies considerably in floristic composition from place to place, and there are few succinct or readily available descriptions in the literature. The most helpful in this respect is an essay on a radius of some 312,600 hectares in the northern part of the province of Buenos Aires, published by Parodi in 1930. It can be regarded as giving a fairly general picture of the pampa grasslands. The author remarks at the outset: "The pampean prairie, in spite of its economic importance, is scientifically the least known of the Argentine phytogeographical formations. . . . The vegetation, apparently monotonous and ordinary, contains a rich and attractive flora. The number of species which can live together in a small surface is surprising. In a virgin prairie in the locality, I have counted in one square metre as many as twelve species flowering simultaneously. On account of agricultural activities, however, these lands have undergone noteworthy modification."

Six main associations, conditioned by the nature of the soil or the environments in which they grow, are distinguished. The fundamental association is described as follows: "The pampean prairie is an extended horizontal plain, extraordinarily monotonous, covered with herbaceous plants, principally grasses, which are only in exceptional cases taller than one metre. There are no trees excepting those which are cultivated. By their extreme dominance the grasses constitute the fundamental elements; there are no exclusively characteristic species to distinguish the pampa from other phytogeographical formations. Many of the species grow in the Chaco, in Mesopotamia or Uruguay, but associated in a different manner. . . . Phytogeographical knowledge up to the present gives no indication of the origin of the pampean flora. . . . A fundamental fact for its comprehension is the rapidity with which certain exotic species have invaded the plain.

* For further information on the lucerne area of Argentina, see pp. 136-141.

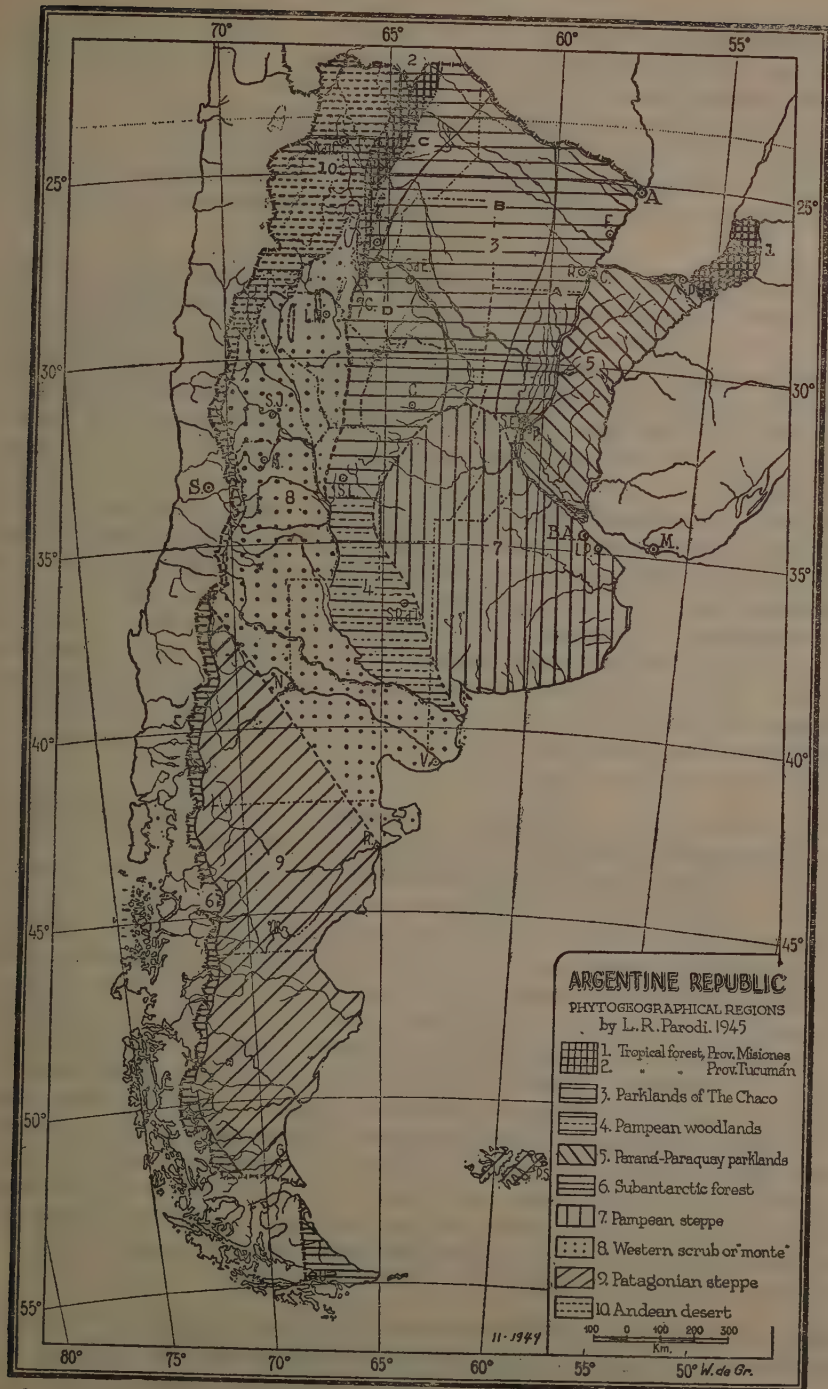


FIG. 6. From "PLANTS AND PLANT SCIENCE IN LATIN AMERICA". Ed. F. VERDOORN, 1945

If no other information were available, one would hardly dare to believe to-day—in view of their dominance—that *Bromus hordeaceus* [*B. mollis*], *Briza minor*, *Koeleria phleoides*, *Ammi visnaga* and the thistles were not original elements of the pampean prairie. An interesting character is the succession of the species during the year ; the plant cover, almost dry in the winter, acquires an intense green and violet colour in the spring, turning to straw-coloured and silver in the summer and tinted by flowers in the autumn. Worthy of special study are the adaptations of the plants which form this community, so distinct in their aspect in accordance with the time at which they are seen."

There is then presented a list of the seventy-two species most common and which most contribute to give the pampa its special character. Of these the grasses comprise two species of *Briza*, two species of *Bromus*, four of *Piptochaetium*, two of *Paspalum*, two of *Panicum*, and three of *Stipa*, and species of *Andropogon*, *Eragrostis*, *Eleusine*, *Hordeum*, *Lolium*, *Melica* and *Poa*. There are reeds and rushes, but the only legumes included in the list are *Desmanthus virgatus*, *Rhynchosia senna* and *Vicia nana*. All the plants listed flower successively from September to May, forming three layers which entirely cover the ground. The first layer comprises plants hardly attaining a height of 5 cm. ; the intermediate layer, which does not exceed 30 cm. in height, includes grasses such as *Panicum hians* [*P. milioides* ?]* and *Piptochaetium montevidense* ; while grasses are prominent in the third layer, the height of which ranges from 40 to 80 cm. Of these *Stipa neesiana*, *S. hyalina*, *Piptochaetium bicolor*, *Andropogon laguroides*, *Bromus brevis*, *B. catharticus*, *Lolium multiflorum* and *Melica* sp. predominate. "The plant species most notable for their extreme abundance are *Stipa hyalina*, *S. neesiana*, *S. papposa*, *Piptochaetium bicolor*, *Bromus catharticus*, *Lolium multiflorum*, *Andropogon leucopogon*, *Eragrostis lugens*, *Gnaphalium* sp., *Conyza chilensis*, *Baccharis coridifolia*, *B. subpingraea* ; they represent the fundamental group around which revolve the modifications and shades of the pampean prairie in time and in space : grey in the winter, violet-green in the spring, straw-coloured and silver in the summer, greenish-yellow in the autumn, and this everywhere.

"Frequently a single one of these species predominates ; this occurs with *Stipa hyalina*, *S. papposa* or *Andropogon laguroides*, the others being well distributed but in a smaller quantity. In this case the extremely monotonous prairie looks like an immense sea whose whitish surface is agitated by the wind, where the view is interrupted only by the horizon or by some far-off dwelling. The panorama is a horizontal line. The surface of the ground is covered by the vegetation ; the predominant grasses such as *Stipa hyalina*, *S. neesiana*, *S. papposa*, *Piptochaetium* sp., *Andropogon laguroides*, *Briza triloba*, are xerophilous, and the tufts which they form are lax thanks to their shoots, frequently extravaginal and geniculate in the lower nodes ; the narrow leaves, convolute and rich in collenchyma, give them a certain consistency to which is attributable the common description of 'strong grasses'. These grasses, to which are associated others which have been proved excellent forage such as *Paspalum dilatatum*, *P. notatum*, *P. distichum*, *Bromus catharticus*, *B. brevis*, *B. erectus*, *Eragrostis lugens*, *Lolium multiflorum*, *Panicum milioides*, *Sporobolus berteroi* [S. *poiretii*], *Setaria geniculata* and *Eleusine tristachya*, on account of the arrangement of their shoots, adpressed to the ground, bear well in their early stages the trampling of cattle. It is probable that trampling causes the scarcity of those close-tufted grasses like *Aristida spegazzinii*, *A. pallens*, *Andropogon consanguineus*, *A. paniculatus* and others which appear in great abundance in places such as the verges of railway lines, inaccessible to cattle.

"Disseminated among the predominant plants grow the therophytes and hemicryptophytes which give character to the pampa, although few have striking panicles like the *Melica*, *Poa*, *Briza*

* *P. hians* is confined to North America. (Chase, 1945.)

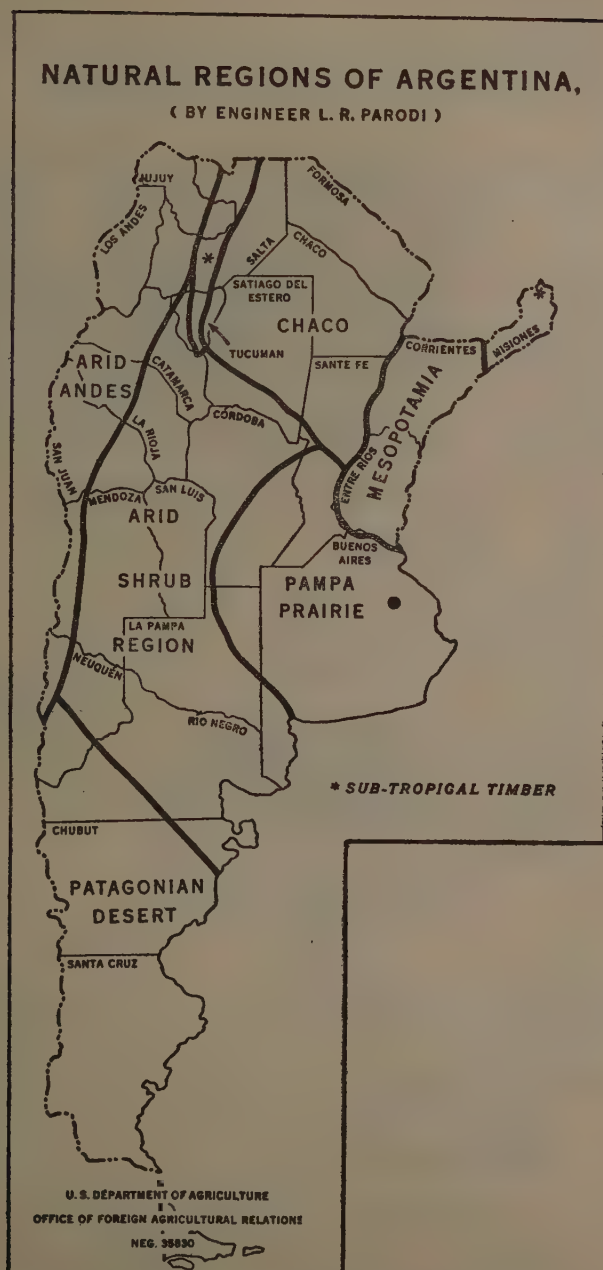


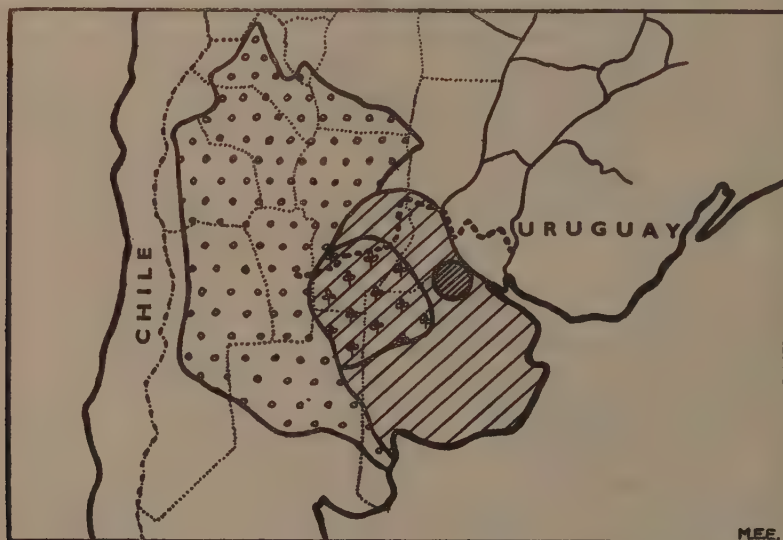
FIG. 7. NATURAL REGIONS OF ARGENTINA
By L. R. PARODI. *For. Agric.* 4.9.1940

and *Eragrostis* species or beautiful flowers such as those of *Verbena chamaedryfolia*, one of the charms of the pampean flora.

"Prairies of this nature, dry in the summer, burn with alarming readiness, and formerly it was customary to fire them in order to induce the formation of fresh shoots, which were avidly cropped by sheep when tender.

"This description represents the commonest type of the regional prairie; it covers the higher and fertile lands that are famous for the cultivation of flax and maize. Notable modifications are observed in accordance with locality and quality of the soil."

In addition to this, the fundamental association, Parodi distinguishes the following: (a) Low grasslands in moister localities, with a dominance of the Paniceae. These are very good for grazing, because they remain green until the middle of summer thanks to the availability of water and the dominance of species of the Paniceae. For arable land they have the disadvantage of becoming unduly invaded by weeds. The dominant grasses are *Paspalum dilatatum*, *P. notatum*, *P. distichum*, *Panicum hians*, *P. bergii*, *Setaria geniculata*, *Sporobolus indicus*, *Eragrostis lugens*, *Eleusine tristachya*, *Polypogon elongatus*, *Hordeum stenostachys*, *H. compressum* and *Stipa hyalina*.



ARGENTINA



Pampa. L. R. Parodi. *Plants and Plant Science in Latin America* 1945 127-32.



Chief Lucerne Area. W. Davies. *Bull. 30, Imp. Bur. Pastures*. 1940



Pampa of the Pergamino Region. L. R. Parodi. *Rev. Fac. Agron. B. Aires* 7. 65-271. 1930.



Southern Limit of Cattle Ticks. P. O. Nyhus in P. E. James, *Latin America* 1941. p. 346.



Monte according to A. Arena. *Ann. Agron., Paris*. 8. 192-219. 1938

FIG. 8. ARGENTINA, SHOWING THE PAMPA, CHIEF LUCERNE AREA, PAMPA OF THE PERGAMINO REGION, SOUTHERN LIMIT OF CATTLE TICKS, AND THE WESTERN SCRUB OR MONTE. Map by M. E. EDWARDS

(b) Grasslands on the shores of streams with a dominance of *Stipa brachychaeta*. These occupy a strip 200 to 300 metres wide along the banks of streams. The vegetation is quite distinct from that previously described; the dominant species, *Stipa brachychaeta*, being a characteristic xerophyte. Other common grasses are *Melica macra* (rare elsewhere), *Stipa* spp., *Piptochaetium hackelii*, *Hordeum compressum*, *Poa lanigera*, etc. Because the land is broken or not readily available for tillage, such lands are generally used for grazing in spite of the mediocre herbage. It is only exceptionally that lucerne is sown in them, although they are optimal for the culture.

(c) Grasslands on the shores of streams with *Stipa papposa* dominant. These may run parallel to the previously-named association, but inside, further away from the watercourse, or on the other bank, in somewhat lower ground. It is grassland with finer herbage, richer flora and a dominance of *Stipa papposa*. The white hairs which adorn the florets of this species give a white, cottony aspect to the area during its flowering and fruiting in December and January. There are associated with it species typical of normal grasslands such as *Stipa hyalina*, *S. neesiana*, *Andropogon laguroides*, *Piptochaetium ovatum*, *P. montevidense*, *Eragrostis lugens*, *Cyperus reflexus*, *Juncus imbricatus* and numerous dwarf species which thickly carpet the ground. These areas are always found in the immediate neighbourhood of streams; they are nowhere very extensive and, although excellent for grazing sheep and fairly good for growing flax, are of only medium value for maize on account of their low fertility and very dry condition in summer.

(d) Undulating grasslands in uneven land. Like the foregoing associations, these grasslands are found on the banks of streams. The land is markedly undulating and frequently alkaline, containing a small proportion of carbonate of sodium. The flora is heterogeneous, on the slopes resembling that of the contiguous pampa, in the lower parts generally halophilous, with *Sporobolus pyramidalis*, *S. poiretii*, *Chloris ciliata*, *Bouteloua megapotamica*, *Schedonnardus paniculatus*, *Stipa papposa*, *Hordeum pusillum*, *Poa lanigera*, *Spergularia* sp., *Dichondra repens*, *Gnaphalium* sp., *Carex bonariensis*, etc., predominating.

(e) Halophyte vegetation of salty grasslands. In lower regions, especially on the shores of streams or in the depressions, on account of the accumulation of small quantities of sodium carbonate there has developed a halophilous flora which deserves separate study. These are typical prairies, frequently extensive, commonly destined for grazing because it is hardly possible to obtain a medium harvest of flax or oats. Apart from its flora, the most notable difference in this type of grassland consists in its intense greenness during the summer, contrasting agreeably with the straw-coloured, visibly dry vegetation of the rest of the pampa. The plants of these lands have an extremely wide distribution in Argentina and throughout South America, several, such as *Sporobolus pyramidalis*, *Distichlis spicata*, *Sida leprosa*, *Heliotropium curassavicum*, etc., growing in the salt soils of practically the whole continent. There can be recognized moderately halophilous vegetation and halophilous vegetation, the former, with *Sporobolus pyramidalis* or *Hordeum pusillum* dominant, forming a short, fine sward rarely exceeding 30 cm. in height, which constitutes good grazing for sheep. The exclusively halophilous vegetation is composed principally of a close sward of *Distichlis spicata* and *Paspalum gayanum*, green nearly all the year round. In spring the appearance of the area is modified by the abundant flowering of *Polypogon elongatus* var. *muticus* and *Hordeum pusillum*, which then disappear.

MODIFICATION

Parodi notes that agriculture, notably the cultivation of maize, flax, wheat and lucerne, and stock raising have caused such profound modifications in the vegetation of the pampa that it is now impossible to conjecture what its composition was before the arrival of the Europeans. The

total number of vascular plants collected amounts to 488, of which those considered indigenous number 318. Of the families represented, the Gramineae predominate and exhibit the largest number of species; the family of the Compositae come next. The Cactaceae, so typical of other Argentine plant formations, are entirely lacking in the pampa. (Parodi, 1930.)

SURVEYS

A. T. Semple, of the U.S. Department of Agriculture, who visited Argentina in April 1943, published a short account of the grasslands of the provinces of Buenos Aires, Entre Ríos and Corrientes in 1945. It is thanks to the courtesy of this author that we are able to present in Tables 1 and 2 what are probably the first published analyses of pampa grazings. Although in the autumn of 1943 (April) the pastures were in a far from typical condition owing to a most severe summer drought, weeds had come in where normally the other species occupied the ground and the stand of grasses in general was thin (Nyhus, 1946), yet the analyses cannot fail to be of interest. (Semple, 1945, 1946.)

TABLE 1

The principal species of grasses and forage legumes found in 122 typical pastures in the humid pampa, principally the province of Buenos Aires, in April, 1943

Areas	Number of pastures examined	Plant	Number of pastures where found	Average percentage of vegetation cover	Range in percentage of cover		
Eastern Buenos Aires from Brondsen to Vidal	13	<i>Distichlis spicata</i>	...	...	15-80		
		<i>Paspalum vaginatum</i>	...	...	15-60		
		<i>Panicum gounisii</i>	...	...	3-30		
		<i>Stenotaphrum secundatum</i>	...	...	1-35		
		<i>Paspalum dilatatum</i>	...	...	1-15		
		<i>Stipa papposa</i> ...	...	...	1-40		
		<i>Scleria geniculata</i>	...	...	1-50		
		<i>Andropogon lagroides</i>	...	...	1-15		
		<i>Sporobolus poiretii</i>	...	...	1-5		
		<i>Paspalum distichum</i>	...	...	5-10		
		Weeds ...	...	...	7-25		
		South-eastern Vidal to Juarez ...	17	Bur clover	...	...	5-30
				<i>Lolium multiflorum</i>	...	...	5-70
<i>Stipa hyalina</i> ...	...			...	5-60		
<i>Distichlis scoparia</i>	...			...	7-20		
<i>Distichlis spicata</i>	...			...	1-13		
<i>Paspalum dilatatum</i>	...			...	1-15		
<i>Elevsine tristiachya</i>	...			...	1-20		
<i>Scleria geniculata</i>	...			...	1-5		
<i>Sporobolus poiretii</i>	...			...	1-10		
<i>Stipa papposa</i> ...	...			...	1-15		
Weeds ...	...			...	10-50		
Southern Juarez to Carhue...	37			Bur clover	...	...	1-65
				Small grain*	...	...	2-100
		<i>Distichlis spicata</i> and <i>D. scoparia</i>	...	...	2-37		
		<i>Elevsine tristiachya</i>	...	...	1-90		
		<i>Stipa hyalina</i>	...	...	1-15		
		<i>Stipa papposa</i> ...	...	...	1-32		
		<i>Sporobolus poiretii</i>	...	...	1-10		
		<i>Paspalum distichum</i>	...	...	1-10		
		<i>Paspalum intermedium</i>	...	...	1-5		
		<i>Aristida pallens</i>	...	...	1-20		
		<i>Sorghum sudanense</i>	...	...	5-45		
		Weeds ...	...	...	5-85		

* Mostly oats and some wheat.

Table 1 continued—

Areas	Number of pastures examined	Plant	Number of pastures where found	Average percentage of vegetation cover	Range in percentage of cover
Northern Junin and Brogado to Rosario and Buenos Aires	55**	<i>Medicago sativa</i> ... Bur clover ... <i>Digitaria sanguinalis</i> ... <i>Bromus catharticus</i> ... <i>Lolium multiflorum</i> ... <i>Cynodon dactylon</i> ... <i>Distichlis spicata</i> ... <i>Eleusine tristachya</i> ... <i>Paspalum distichum</i> ... <i>Paspalum vaginatum</i> ... <i>Setaria geniculata</i> ... <i>Sporobolus argutus</i> ... <i>Stipa hyalina</i> ... <i>Stipa papposa</i> ... Weeds ...	12 32 27 23 4 29 5 15 27 7 11 8 25 12 51	23 26 15 13 20 15 42 3 8 38 6 5 8 6 26	1-65 1-70 1-50 1-35 1-40 1-65 15-75 1-10 1-60 15-80 1-25 1-15 1-40 1-20 5-98
TOTAL	122				

A. T. SEMPLE

** Includes 6 pastures in southern Santa Fe province.

TABLE 2

The principal species of grasses and forage legumes found in 30 typical pastures in April, 1943, in the western part of Buenos Aires province near the centre of chiller steer production

Areas	Number of pastures examined	Plant	Pastures where found	Average percentage of cover	Range in percentage of cover
Western, Rivera to Trenque Lauchen ...	13	<i>Medicago sativa</i> <i>Distichlis scoparia</i> <i>Cenchrus pauciflorus</i> <i>Chloris</i> spp. ... Weeds ...	7 4 8 9 7	71 22 22 39 14	1-98 1-75 1-75 1-90 5-30
West Central, Trenque Lauchen to 9 de Julio	17	<i>Medicago sativa</i> Bar clover ... <i>Digitaria sanguinalis</i> <i>Cynodon dactylon</i> <i>Bromus catharticus</i> Small grain* ... <i>Distichlis spicata</i> Weeds ...	4 7 5 10 6 5 3 17	26 21 31 36 9 53 43 30	10-70 3-70 1-70 1-80 5-15 10-100 5-90 5-90
TOTAL ...	30				

* Chiefly oats.

A. T. SEMPLE

FATTENING LANDS AND REARING LANDS

The Argentine stock raiser recognizes two broadly differentiated types of land in the humid pampa, the "wintering" or fattening zone, which is located in the lucerne lands of the west and also in the south of Córdoba, the south of San Luis, the south of Santa Fé, the south of Entre Ríos and the north-west of the territory of La Pampa; and the rearing or breeding zone, which comprises the central, south-western and eastern parts of the province of Buenos Aires. The cost of land in the rearing zone is much lower than that of the valuable lucerne grazings, and stock raisers who own such land are occupied almost exclusively in the production of young cattle, which are sold at the age of one year to graziers who take them to the fattening zone for wintering and finishing as "baby beef" or as material for the chilling factories. An interesting experiment has been made recently in the use of land in the so-called rearing zone for the fattening of young steers. The estate concerned is situated in the region of the town of Ayacucho in south-eastern Buenos Aires. Sixty, six to eight-month-old, steers from a good Shorthorn herd, selected as far as possible for uniformity of age and type, after grazing for three months on a fenced paddock of the local grass-land ("soft grasses" comprising *Bromus catharticus*, *Paspalum distichum*, *Lolium* sp., *Erodium malacoides*, *Digitaria sanguinalis*, etc.; "hard grasses" *Andropogon saccharoides*, *Stipa* spp., *Andropogon condensatus*, *Poa* sp., etc.), were fattened as follows: September 1938 to January 1939, pasture of oats at the rate of two steers per hectare; January to April, Sudan grass (*Sorghum sudanense*) pasture at the rate of three steers per hectare; April to August, pasture of oats. In spite of apthous fever having reduced the condition of the animals in October 1938, they were finished by 18th August 1939, or in seven months and thirteen days, with a mean live weight of 460 kg., and were sold at the maximum price for chilled beef to a chilling factory, being classified by the latter as "100 per cent chilled superior with a yield of 63·5 per cent clean meat". (Tagle, 1942.) It will be noted that these results were achieved on sown leys of oats and Sudan grass, and it is stated that the lands of the estate concerned would have to be considerably improved before the standard of the present wintering zone is reached.

"Dairying is concentrated in the zone to the south-east of Buenos Aires, extending southward into the eastern part of the humid pampa. Because of the large proportion of swampy land in this section, and because of the cool summers and abundant rains, rich pastures of grass furnish good grazing for herds of high-grade dairy animals. Alfalfa and maize do not prosper." (James, 1941, p. 358.)

STAGES OF DEVELOPMENT

In the development of the pampean plant cover, then, three stages are discernible: the treeless virgin pampa of tall bunchgrasses that was found by the first Spanish colonists; the pampa of the colonial period up to 1810, modified by the introduction of European horses, cattle and sheep, by unregulated grazing and by the possibly incidental introduction of European plants, both weeds and valuable herbage; and the pampa as it is to-day, modified by the intensively developed live stock industry of the past fifty years, by regulated grazing, by agriculture, diversified and otherwise, by conscious improvement in some parts, and by detrimental influences such as erosion in others.

Of the third stage of development, which is not yet complete, the general trend is not readily predictable: it depends greatly upon the measures taken within the next few years. If, however, an attempt be made to balance the factors constituting assets and liabilities respectively in regard to future prospects, the following is seen. Assets. (1) A climate on the whole equable and temperate, with mild winters which make it possible to rear and fatten animals entirely in the open. (2) Fertile

soil. (3) A natural plant cover that, in comparison with its original state, has been improved by the naturalization of valuable introduced herbage plants and by the cultivation of others, notably lucerne. (4) Freedom from the scourge of much South American stock, the ticks which carry Texas fever and to which the better class animals of European stock are highly susceptible. (Fig. 8.)

On the liabilities side there are some serious drawbacks. (a) Reduced productivity of the famous lucerne leys. Attention has already been drawn to the decline in the extent of the lucerne area, and it should be noted that this is possibly due in part to their reduced productivity. "The Argentine lucerne leys, which used to be famous for their longevity (ten to fifteen years), are not productive for more than five or six years at the present day." (Arena, 1938.) "It is a popular misconception that once a lucerne ley is established in these rich La Plata districts, it remains a productive lucerne ley for all time; . . . they are temporary leys with an average life of about five years." (Davies, 1940.) The authors of the Economic Geography of South America note that frequently the lucerne is not planted until the soil reserves have already become seriously depleted (Whitbeck, Williams and Christians, 1940). Nyhus (1940) attributes the reduced productivity to a depletion of subsoil moisture. But there is probably also a connexion between liability (a) and (b), (the next to be enumerated). (b) A certain degree of soil exhaustion, owing to the fact that no manurial treatment has ever been applied to the fertile lands of the pampa apart from that due to the presence of the grazing animal, and that "meat and bone have been sold off these lands for a generation and more, during which time nothing has been done to replenish the plant foods so lost". (Davies, 1940.) The evil is by no means so acute in the pampa as elsewhere, but its result in the occurrence of osteomalacia has been reported. Lerena, of the University of Buenos Aires, in a dissertation on the veterinary aspects of the malady, drew attention to the loss of bone due to the exporting of cattle, advocated the salvage of bones by all possible means and prophesied a day when legislation would become necessary to prevent their export. (Lerena, 1938.) (c) Erosion. Wind erosion has already taken a heavy toll of the middle-west region of Argentina. Reference will be made to this later in the present study; it merely remains here to note that among contributory causes are the ploughing of certain types of grassland, overgrazing, the trampling of cattle about drinking places, insufficient diversification of farming, and activities, including the excessive growing of lucerne and other temporary leys, which bring about a falling of the water table. (Arena and Guiñazú, 1940.)

It is the Argentine agronomist who will eventually balance the sheet. That he has enormous scope has been emphasized by more than one observer. Advance hitherto has been all in the direction of the temporary ley of lucerne or cereals (Davies, 1940, p. 16; Tagle, 1942); but it would appear that even the use of the temporary ley has its dangers in reducing subsoil moisture and increasing erodibility (Arena and Guiñazú, 1940). Moreover, the herbage of oats or sorghum leys that have been allowed to revert to grass is unpalatable, does not seem to improve much with age and has for many years a lower carrying capacity than before ploughing up. The outrun lucerne ley will keep animals in breeding condition, but they will not fatten, and it tends to revert to a grassy association with *Cynodon dactylon*, a species of only summer grazing value, dominant. There is no return to the original pampa cover. (Davies, 1940, pp. 37 and 42.) The value of the correct use of modern seeds mixtures, of more systematic grassland management and the practice of rotational grazing has already been indicated. (Davies, 1940, p. 16.) According to Burkart (1943a, p. 72), also, the grasslands of the pampa present indigenous herbaceous legumes such as *Vicia*, *Lathyrus*, *Adesmia*, *Trifolium*, *Rhynchosia* and others as well as the introduced, naturalized species of *Medicago*, *Melilotus* and *Galega*. It is possible that the encouragement and wider dissemination of the more valuable native legumes might do something to compensate the naturally protein-deficient nature of the pampean herbage.

TYPE 1. GOOD NATURAL GRASSLANDS

(b) Uruguay

Separated from the vast plains of the Argentine pampa by one hundred and fifty miles of the turbid waters of the River Plata, Uruguay presents entirely different contours and in many ways forms a transition between the pampa and the hilly uplands and plateaux of Brazil. It is undulating, with gentle slopes, and there is an abundance of watercourses and clear water. As on the pampa, the prevailing plant cover everywhere is grass, and it is to the faint purplish tinge of the grass-covered slopes that W. H. Hudson's famous description "The Purple Land" is due. (Hudson, 1885.) In contrast to the pampa, a dense fringe of woodland follows the rivers of Uruguay, but nevertheless the wooded areas compose only three per cent of the whole country. Waste land is practically non-existent.

There is a hill near Montevideo described by Magellan, the discoverer, as a hat-shaped mountain on account of its resemblance to the type of hat formerly worn in the Iberian Peninsula and up to recent times by Welshwomen. Viewing Uruguay from the top of this hill, which gives its name to the capital city, Hudson wrote: "Whichever way I turn, I see before me one of the fairest habitations God has made for man: great plains smiling with everlasting spring; ancient woods; swift beautiful rivers; ranges of blue hills stretching away to the dim horizon". (Hudson, 1885.)



FIG. 9. URUGUAY

CLIMATE

Climatically Uruguay is little short of ideal from the pastoral viewpoint, permitting stock to live in the open all the year round. The Köppen symbol is *Cfa*. Throughout the country the average temperatures of the coldest month are approximately 50° F. (10° C.) ; while at Montevideo the average of the warmest month is 72° F. (22·2° C.) ; a little lower than that of Buenos Aires. Rainfall, the average of which ranges from 38 inches (965·2 mm.) at Montevideo to nearly 50 inches (1,270 mm.) in the north, is evenly distributed throughout the year with no regular season of excessive rain or of drought. There is an irregularity in the total fall from year to year, not so serious a matter for pasture grasses as for crops, but periods of prolonged drought are rare. (James, 1941.)

ANIMAL INDUSTRY

"Uruguay is justifiably considered a stock-raising country *par excellence*." (Boerger, 1935.) "Uruguay is a country of one main resource and one main industry. The natural wealth of the country lies in its soil and in its wide rolling pastures, clad in nutritious grasses, somewhat richer than the native grasses of Argentina." (Whitbeck, Williams and Christians, 1940.) A glance at James' map of the land use of Uruguay shows practically the whole land to be devoted to live stock ranching without agriculture, only a relatively small strip along the southern shore being occupied by commercial grain agriculture. (James, 1941, p. 378.) The natural pastures occupy 82·5 per cent. of the total area of the country and 91·7 per cent of the land considered suitable for agriculture and animal husbandry. (Spangenberg and collaborators, 1941.)

The history of stock raising in Uruguay resembles that of Argentina up to a certain point. In colonial days the country formed part of its southern neighbour and was known as "The Eastern Shore" (La Banda Oriental). Cattle were introduced about 1603, ran wild and multiplied, and their wasteful exploitation became the purview of the gaucho, whose sway seems to have lasted slightly longer in Uruguay than in Argentina. Gradually land holdings became established ; boundaries were fixed, first in the neighbourhood of the La Plata shore, the early trade being mostly with Argentina, and by degrees spread further north. High-grade wool and mutton sheep were introduced in 1840 ; from 1850 onwards there was somewhat the same upward trend in the live-stock industry as in Argentina ; barbed wire fences were erected to divide and subdivide ranches and grazings (1875 onwards) ; roads were built, no difficulty being encountered as in Argentina with its lack of gravel ; and from 1904 meat chilling and packing plants were established. From 1906 up to the end of the first world war the improvement of cattle quality was very rapid, and few creole animals remain at the present time. To-day Uruguay is second only to Argentina in meat exports. In 1939, 10 per cent of the meat and 37 per cent of the wool exports of Latin America came from Uruguay.

In spite of these facts, however, the progress of the industry has by no means run parallel to that of Argentina. Yahn, in a study of the cattle returns from 1850 onwards, showed that by 1933 Uruguay's stock of cattle had remained at approximately the same level for the past twenty-five years, while both the net yield and the quality of the meat produced had diminished. He found extraordinary fluctuations, also, in the statistics for sheep raising from 1850, and noted that the mean production of wool per sheep had remained stationary for about twenty years. (Yahn, 1933.) Sheep play an important part in the economic life of the country. Spangenberg and collaborators record (1941) that the average amount of stock kept between 1900 and 1937 was seven million head of cattle and eighteen million sheep, or 0·5 cattle and 1·2 sheep per hectare, and that there was little variation in quantity during this period.

DETERIORATION OF THE GRASSLANDS

It is considered that the stationary position of the livestock industry is in direct relation to the deterioration of the natural grazings. Attention was called to this deterioration as early as 1878 by a Government Committee (Yahn, 1933; the urgency of the subject was stressed by Spangenberg in 1930. Boerger writes 1935: "The Uruguayan grasslands, left entirely to themselves, have suffered deterioration in the course of the centuries. . . . The deterioration of the sward is expressed in the first place in its Europeanized aspect, resulting from the introduction of grasses and pasture weeds emanating in the main from Europe. But it is seen also in the gradual suppression of the valuable indigenous herbage (above all of several *Paspalum* species) by native grasses of less value, especially by the hard grasses of different *Stipa* species which are referred to collectively under the name 'espartillo'. A special type of vegetation is presented in areas which were formerly cultivated as arable land and have reverted to grassland through spontaneous seeding. The dominant grasses here are *Digitaria sanguinalis*, *Echinochloa colona*, *E. oryz-galli*, *Cynodon dactylon*, *Paspalum distichum*, and *Setaria geniculata*. Of the Leguminosae, *Vicia villosa* and related forms are found. There are in addition other species which may be regarded as weeds: *Lolium temulentum*, *Echium violaceum* and *Sorghum halepense*." (Boerger, 1935.) The lucerne ley of Argentine type is seldom seen in Uruguay.

CHANGE IN THE PLANT COVER

As in the humid pampa, so in Uruguay the raising of livestock for centuries, and especially the industry of the last fifty years or so, have brought about a transformation of the plant cover, one which in Uruguay has been verified by its own experts to be an advanced stage of deterioration. (Spangenberg, 1930. Boerger, 1935, etc. Yahn, 1933.) And this stage of deterioration coincides with a complete change in the demands made on the cattle grazer by the requirements of the meat market. He now has to supply younger and better animals than formerly: the demand is for "baby beef". While this saves him a certain amount of risk, at the same time more exacting nutritional requirements are inevitable. Better herbage, rich in nitrogen and mineral content, is essential for high-grade young animals. (Yahn, 1933.)

MEASURES TO STOP THE DETERIORATION

Happily, a stage of crisis has been recognized, and prompt and far-reaching measures to meet it have been taken. With a view to co-ordinating the efforts represented in the large amount of valuable work already undertaken by the Montevideo Agricultural College, by the three Agricultural Experiment Stations, the La Estanzuela Institute and private individuals, the Uruguayan Government appointed in 1935 a special Commission to study the national grassland and forage crop problem under the energetic chairmanship of Dr. A. Boerger, Director of the La Estanzuela Institute. The Commission has had the powerful support of the Ministry of Agriculture, and the work already accomplished by it must be of great economic worth to the country.

It is comprehensible that botanical research in a country such as Uruguay should, from the outset, be devoted in the main to the dominant herbaceous flora and agricultural research to the utilization of that flora. In this connexion attention is drawn to a bibliography of Uruguayan work compiled by Boerger, containing 325 references dating from 1776 to 1940, arranged in chronological order. (Boerger, 1940.) On account of the abundance of material descriptive of the Uruguayan grasslands that has been published, especially since the beginning of the present century, its review in brief presents difficulty, and it is believed that a more detailed account of a recent publication of the National Commission on the Forage Problem will best indicate the present composition of the grasslands.

SURVEY

It was realized by the Commission that, in order to solve the multitudinous problems that have arisen during the course of centuries, a comprehensive survey of the country's present resources in soil and herbage, in their relation the one to the other and to the climate, was of first importance. This survey has now been made, and its results have been published in the *Rev. Fac. Agron. Montevideo*, 1941.

Four experts working under the auspices of the National Commission who are also members of the agricultural staff of the University of Montevideo, namely, G. E. Spangenberg, J. G. Nores, L. A. Montedónico and C. A. Fynn, made a close study of twenty-three representative plots of grassland situated at different places in sixteen of the eighteen Departments of Uruguay from the autumn of 1937 to the autumn of 1938. The plots, each eleven by eleven metres in size, were fenced off, a botanical analysis of the herbage was made in each case, and an area of exactly ten by ten metres was cut quarterly. When circumstances required it the location of the plot was varied, because the change of use—cutting instead of grazing—produced, in accordance with the type of pasture, modifications in constitution that were sometimes very pronounced.

Of the extremely comprehensive studies made of these plots, the botanical composition of the sward is here of primary interest. In the report, a first broad classification is made whereby the grass species fall into two categories, the tender and the hard grasses. The second class contains those grasses commonly referred to by agriculturists as "coarse" or "bitter" grasses, or by the collective name of "espartillos". They are useful for fodder only in the very early stages of growth, and consist of species of *Stipa*, *Piptochaetium*, *Aristida*, *Andropogon lateralis*, *A. condensatus* and *A. pellitus*, *Paspalum plicatulum*, *Elyonurus*, *Trachypogon montufari*, *Danthonia* and some others. Legumes are not included in these two groups. A detailed account of the plant species found to be dominant at the different seasons of the year is presented in Table 3.

TABLE 3
URUGUAY

DOMINANT SPECIES IN THE SWARD

Notes.—1. The figures represent proportions quoted as percentage cover.

2. "Hard grasses" are coarse grasses of inferior nutritive worth or valuable only in the early stages of growth.

They comprise species of *Stipa*, *Piptochaetium*, *Aristida*, *Andropogon lateralis*, *A. condensatus*, *A. pellitus*, *Paspalum plicatum*, *Elyonurus*, *Trachypogon montifurci*, *Danthonia* and some others. (See p. 19.)

3. The "tender grasses" are the more valuable species.

4. *Bromus catharticus* = *B. unioloides*. *Sporobolus poiretii* = *S. berterianus*. *Paspalum urvillei* = *P. lamnagali*.

Department	Locality	Autumn March—May	Winter June—August	Spring September—November	Summer December—February
Lavalleja	Valle Fuentes	<i>Lolium multiflorum</i> , <i>Bromus catharticus</i> , <i>Avena sterilis</i> , <i>Paspalum dilatatum</i> , <i>Setaria caespitosa</i> (50); <i>Erodium cicutarium</i> (20); <i>Medicago arabica</i> (20); <i>Echium plantagineum</i> , <i>Rumex</i> , <i>Piptochaetium</i> , <i>Stipa</i> , etc.	<i>Lolium multiflorum</i> , <i>Bromus catharticus</i> , <i>Poa annua</i> (35), <i>Erodium cicutarium</i> , <i>Echium plantagineum</i> (30); <i>Medicago arabica</i> and <i>M. hispida</i> (20); <i>Silybum</i> , <i>Carthamus</i> , <i>Centauarea</i> , etc.	<i>Lolium multiflorum</i> , <i>Bromus catharticus</i> and <i>B. mollis</i> , <i>Hordeum murinum</i> , <i>Avena sterilis</i> (80); <i>Echium plantagineum</i> , <i>Rumex</i> , <i>Erodium cicutarium</i> (15); <i>Centauarea</i> , <i>Silybum</i> , <i>Carduus</i> , etc., and some spp. of <i>Stipa</i> (very few).	
Lavalleja	Valle Fuentes	<i>Medicago arabica</i> (50); <i>Lolium multiflorum</i> , <i>Bromus catharticus</i> , <i>Avena sterilis</i> , <i>Paspalum dilatatum</i> , <i>Andropogon saccharoides</i> , <i>Setaria caespitosa</i> (30); <i>Stipa</i> , <i>Piptochaetium</i> , <i>Sporobolus</i> (10); <i>Echium plantagineum</i> (5); <i>Silybum maritimum</i> , <i>Centauarea</i> , <i>Cyperus</i> , <i>Juncus</i> , etc.	<i>Medicago</i> (50); <i>Lolium</i> , <i>Bromus</i> , <i>Poa</i> (35); <i>Stellaria media</i> , <i>Echium plantagineum</i> , <i>Silybum</i> (10); <i>Cynara</i> , <i>Stipa</i> spp., etc.	<i>Lolium multiflorum</i> , <i>Bromus catharticus</i> and <i>B. mollis</i> , <i>Hordeum murinum</i> , <i>Avena sterilis</i> (70); <i>Echium plantagineum</i> , <i>Rumex</i> (20); <i>Stipa charruana</i> (5); <i>Carthamus</i> , etc.	
Soriano	Colol6	<i>Andropogon saccharoides</i> (50); <i>Paspalum dilatatum</i> and <i>P. notatum</i> (20); <i>Silybum maritimum</i> (15); <i>Conyza chilensis</i> (10); <i>Setaria</i> , <i>Digitaria sanguinalis</i> , <i>Eleusine tristachya</i> , <i>Sporobolus</i> , etc. (There was much very tender clover.)	Tender grasses (60); <i>Medicago hispida</i> and <i>M. arabica</i> (15); <i>Silybum</i> (5), <i>Conyza chilensis</i> (15); <i>Centauarea</i> , etc.	<i>Lolium multiflorum</i> , <i>Bromus catharticus</i> (40); <i>Stipa hyalina</i> and <i>S. neesiana</i> (45); <i>Sporobolus poiretii</i> , <i>Briza</i> , <i>Medicago hispida</i> (5); <i>Carthamus</i> , <i>Centauarea</i> .	<i>Andropogon saccharoides</i> (60); <i>Eleusine tristachya</i> , <i>Sporobolus poiretii</i> , <i>Briza</i> , etc.

Table 3 continued—

Department	Locality	Autumn March—May	Winter June—August	Spring September—November	Summer December—February
Rocha	Don Carlos (Uplands)	<i>Cynodon dactylon</i> (95) ; <i>Paspalum dilatatum</i> (2) ; <i>Aira caryophylla</i> (2) ; <i>Andropogon saccharoides</i> , <i>Sporobolus</i> , <i>Setaria viridis</i> (1).	Tender grasses (40) ; hard grasses (50) ; <i>Oxalis</i> (5) ; etc.	<i>Cynodon dactylon</i> (95) ; <i>Lolium multiflorum</i> , <i>Bromus cartharticus</i> , <i>Briza minor</i> , <i>Aira caryophylla</i> , <i>Setia neesiana</i> , <i>Melica</i> sp., <i>Juncus</i> sp.	<i>Cynodon dactylon</i> (100).
Rocha	Don Carlos (Lowlands and plain)	<i>Stenotaphrum americanum</i> , <i>Paspalum dilatatum</i> , <i>Andropogon saccharoides</i> , <i>Setaria viridis</i> (45) ; <i>Piptochaetium</i> , <i>Stipa</i> spp., <i>Aristida</i> spp., <i>Sporobolus poiretii</i> , <i>Aira caryophylla</i> (30) ; <i>Adesmia bicolor</i> , <i>Trifolium polymorphum</i> (20) ; <i>Solidago microglossa</i> , <i>Juncus</i> , etc.	Tender grasses (30) ; hard grasses (35) ; <i>Adesmia bicolor</i> , <i>Trifolium polymorphum</i> (20) ; etc.	<i>Stipa</i> spp., <i>Piptochaetium montevidense</i> and <i>P. stipoides</i> , <i>Aristida murina</i> , <i>Festuca bromoides</i> , <i>Dianthionia</i> (60) ; <i>Stenotaphrum americanum</i> , <i>Polypogon elongatus</i> , <i>Paspalum dilatatum</i> , <i>Andropogon saccharoides</i> , <i>Setaria geniculata</i> (30) ; <i>Adesmia bicolor</i> , <i>Trifolium polymorphum</i> (10).	Tender grasses including especially <i>Paspalum dilatatum</i> and <i>Andropogon saccharoides</i> (45) ; hard grasses (30) ; <i>Adesmia bicolor</i> , <i>Trifolium polymorphum</i> (20).
Rocha	Cebollati (Lowlands)	<i>Stenotaphrum americanum</i> , <i>Paspalum dilatatum</i> , <i>Setaria</i> spp. (50) ; <i>Sporobolus poiretii</i> (30) ; <i>Juncus</i> sp., <i>Hydrocotyle bonariensis</i> , <i>Rumex</i> sp. (10).	<i>Poa annua</i> , <i>Stenotaphrum americanum</i> , <i>Lolium multiflorum</i> (80) ; <i>Polygala australis</i> , <i>Cerastium glomeratum</i> , <i>Cardamine</i> , <i>Rumex</i> , <i>Hydrocotyle</i> (15) ; <i>Adesmia</i> sp. (little).	<i>Lolium multiflorum muticum</i> (80) ; <i>Polypogon elongatus</i> (15) ; <i>Paspalum dilatatum</i> , <i>Briza minor</i> , <i>Juncus chamissonis</i> , <i>Sisyrinchium</i> , <i>Plantago</i> , <i>Adesmia bicolor</i> .	<i>Stenotaphrum americanum</i> , <i>Paspalum</i> spp., <i>Eragrostis</i> , <i>Lolium multiflorum</i> (60) ; <i>Sporobolus poiretii</i> (30) ; <i>Adesmia bicolor</i> (little).
Salto	Itapebí (Sandy soil)	<i>Sporobolus poiretii</i> , <i>Elyonurus candidus</i> (50) ; <i>Paspalum dilatatum</i> , <i>Paspalum notatum</i> , <i>Andropogon saccharoides</i> , <i>Eragrostis bahiensis</i> , <i>E. neesii</i> and <i>E. pilosa</i> , <i>Setaria gracilis</i> , <i>Axonopus compressus</i> , <i>Rotboellia compressa</i> (45) ; <i>Baccharis coridifolia</i> , <i>Gerardia communis</i> , <i>Bulbostylis juncoides</i> , <i>Polygala verticillata</i> , <i>Pterocaulon subvirgatum</i> , <i>Rhynchosia senna</i> , <i>Hemima salicifolia</i> and <i>Iulacrotum montevidensis</i> .	Hard grasses (40) ; tender grasses (50) ; <i>Rhynchospora luzuliformis</i> , <i>Oxalis amara</i> .	<i>Andropogon ternatus</i> (45) ; <i>Andropogon condensatus</i> (20) ; <i>Paspalum plicatulum</i> and <i>Briza</i> sp. (10) ; <i>Paspalum dilatatum</i> (5) ; <i>Sporobolus poiretii</i> (5) ; <i>Rotboellia seloana</i> , <i>Setaria geniculata</i> , <i>Aristida pallens</i> , <i>Stipa neesiana</i> .	<i>Sporobolus poiretii</i> (35) ; <i>Andropogon ternatus</i> (25) ; <i>Axonopus compressus</i> (20) ; <i>Rotboellia seloana</i> , <i>Paspalum dilatatum</i> , <i>Paspalum notatum</i> , <i>Setaria geniculata</i> , <i>Chloris bahiensis</i> , <i>Leptocoryphum lanatum</i> , <i>Eragrostis pilosa</i> .

Table 3 continued—

Department	Locality	Autumn March—May	Winter June—August	Spring September—November	Summer December—February
Paysandú	Queguay	<i>Medicago arabica</i> and <i>M. hispida</i> ; (of small size, but covers a large part of the ground); <i>Andropogon saccharoides</i> (dry) and <i>P. dilatatum</i> (15); <i>Setaria caespitosa</i> and <i>S. gracilis</i> ; <i>Elyusine indica</i> ; <i>Eragrostis pilosa</i> ; <i>Panicum laxum</i> , <i>Rotboellia compressa</i> , <i>Paspalum urvillei</i> , <i>Cynodon dactylon</i> (30); <i>Baccharis coriifolia</i> , <i>Cirsium lanceolatum</i> , <i>Cyperus vegerus</i> , <i>Cuphea glutinosa</i> , <i>Juncus</i> , etc.	<i>Medicago arabica</i> and <i>M. hispida</i> (30); <i>Adesmia bicolor</i> and <i>Vicia linearifolia</i> ; tender grasses (30); hard grasses (40).	Hard grasses; <i>Stipa hyalina</i> , <i>Meica</i> sp. (70); <i>Paspalum dilatatum</i> and <i>Setaria caespitosa</i> (10); <i>Andropogon saccharoides</i> and <i>A. ternatus</i> (15); <i>Cenitorea calcitrapa</i> , <i>Cynara caratunculus</i> , <i>Eryngium nudicaule</i> , <i>Cyperus</i> , etc.	<i>Sporobolus poiretii</i> (25); <i>Paspalum dilatatum</i> (30); <i>Andropogon saccharoides</i> (20); <i>Elyusine tristachya</i> , <i>Setaria</i> sp. and <i>S. caespitosa</i> , <i>Rotboellia selloana</i> , <i>Cynodon dactylon</i> , <i>Chloris uliginosa</i> , <i>Andropogon ternatus</i> , <i>Stipa hyalina</i> , <i>Paspalum urvillei</i> .
Salto	Itapebí (Clay soil)	<i>Andropogon saccharoides</i> , <i>Paspalum notatum</i> , <i>Chloris bahiensis</i> , <i>Bouteloua multiseta</i> , <i>Eragrostis pilosa</i> , <i>Setaria gracilis</i> , <i>Rotboellia selloana</i> (80); <i>Stipa</i> spp. <i>Andropogon condensatus</i> , <i>Paspalum quadrifarium</i> , <i>Elyonurus candidus</i> (15); <i>Adesmia bicolor</i> and <i>A. punctata</i> ; <i>Baccharis coriifolia</i> , <i>Berroa gnaphaloides</i> , <i>Juncus imbricatus</i> , <i>Anemone decapetala</i> , <i>Spilanthes amnicoides</i> , <i>Oralis</i> .	<i>Adesmia punctata</i> and <i>A. bicolor</i> (little). Various tender grasses.	<i>Adesmia bicolor</i> , <i>Rhynchosia senna</i> , <i>Caesalpinia rubicunda</i> ; <i>Andropogon ternatus</i> (30); <i>Andropogon saccharoides</i> (15); <i>Aristida pallens</i> (30); <i>Andropogon condensatus</i> (15); <i>Bouteloua megapotamica</i> , <i>Rotboellia selloana</i> , <i>Eragrostis bahiensis</i> , <i>Chloris sp.</i> , <i>Brixa</i> sp., <i>Piptochaetium ovatum</i> .	<i>Andropogon saccharoides</i> , <i>Paspalum notatum</i> , <i>Setaria geniculata</i> , <i>Chloris bahiensis</i> , <i>Eragrostis meessii</i> and <i>E. pilosa</i> , <i>Elyonurus candidus</i> , <i>Elyusine tristachya</i> , <i>Andropogon condensatus</i> , <i>Juncus</i> , <i>Cyperus reflexus</i> , etc.
Rivera	Batoví	<i>Paspalum dilatatum</i> and other tender grasses (35); <i>Andropogon condensatus</i> , <i>Stipa</i> spp., <i>Piptochaetium</i> and other hard grasses (40); <i>Baccharis gemistelloides</i> ; <i>Baccharis coriifolia</i> , <i>Vernonia flexuosa</i> , <i>Eryngium nudicaule</i> , <i>Erianthus trinii</i> (25).	Tender grasses (40); hard grasses (30); <i>Oralis</i> sp.	<i>Andropogon saccharoides</i> , <i>Paspalum dilatatum</i> , <i>Paspalum notatum</i> , <i>Setaria</i> spp., <i>Chloris</i> , etc., (50); <i>Andropogon condensatus</i> , <i>Andropogon ternatus</i> , <i>Stipa</i> spp. and <i>Piptochaetium</i> (little) (30); <i>Vernonia</i> , <i>Eryngium</i> , <i>Erianthus trinii</i> .	<i>Paspalum notatum</i> (dominant) and <i>P. dilatatum</i> , <i>Chloris</i> sp., <i>Setaria</i> spp. (50); <i>Andropogon condensatus</i> , <i>Andropogon ternatus</i> , <i>Stipa</i> spp., <i>Piptochaetium</i> spp. (30).

Table 3 continued—

Department	Locality	Autumn March—May	Winter June—August	Spring September—November	Summer December—February
Rio Negro	Bellaco	<i>Paspalum dilatatum</i> and <i>P. notatum</i> (30); <i>Setaria caespitosa</i> (12); <i>Andropogon saccharoides</i> (15); <i>Cynodon dactylon</i> (12); <i>Paspalum urvillei</i> (2); <i>Bromus catharticus</i> , <i>Bouteloua multiseta</i> , <i>Stipa hyalina</i> , <i>Oxalis</i> , <i>Conyza chilensis</i> ; <i>Centaurea calcitrapa</i> , <i>Eryngium nudicaule</i> , <i>Mangrivicarpus</i> , <i>Verbena chamaedryfolia</i> , <i>Cynara cardunculus</i> , <i>Chaptalia pilosellodes</i> and <i>C. exscapa</i> , <i>Eupatorium bartsiiifolium</i> , etc. (<i>Medicago hispida</i> covering part of the plot, but plants of small size; also some representatives of <i>Medicago arabica</i> and <i>Trifolium polymorphum</i>).	<i>Medicago hispida</i> scattered over a large part of the plot, but plants of small size. The grasses and herbaceous plants very short, not tall enough to cut.	<i>Bromus catharticus</i> (15); <i>Lolium multiflorum</i> (10); <i>Paspalum dilatatum</i> (10); <i>Andropogon saccharoides</i> (10); <i>Bouteloua multiseta</i> (10); <i>Stipa hyalina</i> and other spp. (10); <i>Andropogon condensatus</i> (8); <i>Aristida pallens</i> (4); <i>Paspalum urvillei</i> (2); <i>Medicago hispida</i> and <i>M. arabica</i> , <i>Baccharis coridifolia</i> , <i>Eryngium nudicaule</i> , <i>Centaurea calcitrapa</i> .	<i>Andropogon saccharoides</i> (50); <i>Paspalum dilatatum</i> (25); <i>Setaria caespitosa</i> (10); <i>Paspalum notatum</i> , <i>Stipa</i> spp., <i>Medicago hispida</i> and <i>M. arabica</i> , etc.
Florida	Isla Mala	<i>Stipa neesiana</i> , <i>Stipa hyalina</i> and <i>S. papposa</i> , <i>Piptochaetium</i> spp., <i>Sporobolus poiretii</i> (50); <i>Axonopus compressus</i> , <i>Stenotaphrum americanum</i> , <i>Paspalum dilatatum</i> and <i>P. notatum</i> , <i>Eragrostis neesii</i> and <i>E. lugens</i> , <i>Andropogon saccharoides</i> (30); <i>Trifolium polymorphum</i> , <i>Adesmia bicolor</i> , <i>Desmanthus virgatus</i> (15); <i>Berroa gnaphalioides</i> , <i>Gnaphalium purpureum</i> , <i>Mangrivicarpus selosus</i> , <i>Spergula levis</i> , <i>Sotima sessilis</i> , <i>Cyperus reflexus</i> , <i>Juncus chamissonis</i> , <i>Erigeron</i> , <i>Aster squamatus</i> , <i>Richardsonia stellularis</i> , <i>Chaptalia exscapa</i> , <i>Baccharis coridifolia</i> .	Tender grasses (50); hard (35); legumes (4); other species (10).	<i>Stipa neesiana</i> , <i>Stipa hyalina</i> and <i>S. papposa</i> , <i>Piptochaetium</i> spp., <i>Sporobolus</i> (30); <i>Axonopus compressus</i> , <i>Stenotaphrum americanum</i> , <i>Paspalum notatum</i> and <i>P. dilatatum</i> , <i>Andropogon saccharoides</i> , <i>Eragrostis lugens</i> and <i>E. neesii</i> (50); <i>Trifolium polymorphum</i> , <i>Adesmia bicolor</i> (5); <i>Berroa</i> , <i>Gnaphalium</i> , <i>Cyperus</i> , <i>Juncus</i> , <i>Chaptalia exscapa</i> .	

Table 3 continued—

Department	Locality	Autumn March—May	Winter June—August	Spring September—November	Summer December—February
Flores	Paso de la Cadena (Crystalline formation)	<i>Digitaria sanguinalis</i> , <i>Axonopus compressus</i> , <i>Paspalum notatum</i> , <i>Chloris bahiensis</i> , <i>Eragrostis nesii</i> and <i>E. vivascens</i> , <i>Andropogon saccharoides</i> , <i>Panicum decipiens</i> (65); <i>Stipa</i> spp., <i>Piptochaetium</i> spp., <i>Sporobolus poiretii</i> (20); <i>Trifolium polymorphum</i> (10); <i>Chaptalia piloselloides</i> , <i>Scutellaria rumicifolia</i> , <i>Juncus microcephalus</i> , <i>Juncus chamissonis</i> , <i>Cyperus reflexus</i> , <i>Bercoa gnaphalioides</i> , <i>Hypochaeris tweedii</i> , <i>Chevreulia stolonifera</i> , <i>Calydorea nuda</i> (4); <i>Baccharis coridifolia</i> .	Tender grasses (60); hard grasses (15); <i>Trifolium polymorphum</i> (10); <i>Medicago hispida</i> ; and other species (15).	<i>Axonopus compressus</i> , <i>Paspalum notatum</i> , <i>Paspalum dilatatum</i> , <i>Andropogon saccharoides</i> (together dominant) (15); <i>Stipa</i> spp., <i>Piptochaetium</i> , <i>Panicum</i> (15); <i>Trifolium polymorphum</i> (7); <i>Medicago hispida</i> .	
Flores	Paso de la Cadena (Basalt and calcareous soil)	<i>Stipa</i> spp. (especially <i>S. papposa</i>), <i>Panicum decipiens</i> , <i>Piptochaetium</i> (together dominant) (50); <i>Paspalum dilatatum</i> , <i>Roboelia selloana</i> , <i>Paspalum notatum</i> , <i>Andropogon saccharoides</i> , <i>Setaria</i> spp., <i>Leptocoryphium lanatum</i> (25); <i>Trifolium polymorphum</i> (10); <i>Bercoa gnaphalioides</i> , <i>Cyperus reflexus</i> , <i>Chaptalia piloselloides</i> , <i>Dichondra repens</i> , <i>Chaptalia excelsa</i> , <i>Margyricarpus setosus</i> , <i>Geranium molle</i> , <i>Erigeron bonariensis</i> , <i>Rebunium athlerodes</i> , <i>Aster squamatus</i> , <i>Oxalis selloana</i> and <i>O. amara</i> (10); <i>Baccharis coridifolia</i> , <i>Carthamus lanatus</i> , <i>Eryngium nudicaule</i> .	Tender grasses (40); hard grasses (40); <i>Medicago hispida</i> and <i>Trifolium polymorphum</i> (10).	<i>Paspalum dilatatum</i> , <i>Roboelia selloana</i> , <i>Paspalum notatum</i> , <i>Setaria caespitosa</i> , <i>Andropogon saccharoides</i> , <i>Panicum decipiens</i> (50); <i>Stipa</i> spp., <i>Piptochaetium</i> (25); <i>Medicago hispida</i> and <i>Trifolium polymorphum</i> (10).	
Durazno	Molles (Cretaceous alluvium and basalt)	<i>Stipa</i> spp., <i>Piptochaetium</i> , <i>Sporobolus</i> (20); <i>Paspalum notatum</i> and <i>P. dilatatum</i> , <i>Andropogon saccharoides</i> ,	Tender grasses (55); hard grasses (5); Legumes (20).	<i>Paspalum dilatatum</i> , <i>Paspalum notatum</i> , <i>Axonopus compressus</i> , <i>Stenotaphrum americanum</i> , <i>Andropogon</i>	<i>Paspalum dilatatum</i> and <i>P. notatum</i> , <i>Axonopus compressus</i> , <i>Setaria</i> spp. (absolutely dominant) (90).

Table 3 continued—

Department	Locality	Autumn March—May	Winter June—August	Spring September—November	Summer December—February
Durazno	Molles (Basalt)	<i>Roboelia selloana</i> (40); <i>Medicago hispida</i> and <i>Trifolium polymorphum</i> (20); Cyperaceae (4).	Tender grasses (75); legumes (10); hard grasses (practically none).	<i>sacharoides</i> , <i>Roboelia selloana</i> , <i>Setaria</i> spp., <i>Chloris</i> (75); <i>Stipa</i> spp., <i>Piptochaetium</i> spp. (5).	<i>Paspalum notatum</i> , <i>Paspalum dilatatum</i> , <i>Andropogon saccharoides</i> , <i>Axonopus compressus</i> , <i>Stenotaphrum americanum</i> , <i>Setaria caespitosa</i> , <i>Andropogon saccharoides</i> (85); <i>Medicago hispida</i> and <i>Trifolium polymorphum</i> (10).
Cerro Largo	Rio Branco	<i>Axonopus compressus</i> , <i>Andropogon saccharoides</i> , <i>Paspalum notatum</i> , <i>Eragrostis bahiensis</i> , <i>E. neesii</i> and <i>E. pilosa</i> , <i>Stenotaphrum americanum</i> , <i>Chloris ciliata</i> (40); <i>Andropogon ternatus</i> , <i>Andropogon condensatus</i> , <i>Sporobolus poiretii</i> (50); Cyperaceae and Juncaceae.	Tender grasses (20); hard grasses (45); <i>Verbena</i> , <i>Rhynchospora luzuliformis</i> , <i>Oxalis amara</i> , <i>Linum selaginoides</i> , <i>Polygala australis</i> .	<i>Andropogon saccharoides</i> and <i>A. ternatus</i> , <i>Paspalum notatum</i> , <i>Briza triloba</i> , <i>Briza minor</i> , <i>Setaria geniculata</i> , <i>Eragrostis bahiensis</i> , (27); <i>Aristida murina</i> , <i>Paspalum plicatulum</i> , <i>Andropogon lateralis</i> , <i>Andropogon consanguineus</i> , <i>Dianthionia cirrhata</i> , <i>Piptochaetium montevidense</i> , <i>Piptochaetium stipoides</i> , <i>Stipa neesiana</i> (70); <i>Rhynchospora luzuliformis</i> .	<i>Andropogon saccharoides</i> , <i>Axonopus compressus</i> , <i>Eragrostis bahiensis</i> and <i>E. neesii</i> , <i>Chloris ciliata</i> , <i>Paspalum dilatatum</i> and <i>P. notatum</i> (50); <i>Andropogon condensatus</i> , <i>Sporobolus poiretii</i> , <i>Andropogon lateralis</i> (40).
Paysandú	Piedras Coloradas	<i>Paspalum plicatulum</i> , <i>Paspalum notatum</i> , <i>Andropogon saccharoides</i> , <i>Axonopus compressus</i> , <i>Setaria gracilis</i> , <i>Eragrostis pilosa</i> , <i>Panicum bergii</i> , <i>Chloris</i> sp. (70); <i>Andropogon condensatus</i> , <i>Sporobolus tenacissimus</i> , <i>Stipa</i> spp. (20); <i>Trifolium polymorphum</i> , <i>Vicia linearifolia</i> , <i>Adesmia punctata</i> , <i>Medicago hispida</i> , <i>Rhynchosia senna</i> (5); <i>Juncus</i> , <i>Geranium pusillum</i> , <i>Gnaphalium purpureum</i> , <i>Oxalis</i> sp.	Tender grasses (80); <i>Adesmia punctata</i> beginning to shoot. <i>Oxalis</i> sp., <i>Baccharis coridifolia</i> .	<i>Briza minor</i> , <i>Briza triloba</i> , <i>Axonopus compressus</i> , <i>Bromus erectus</i> , <i>Eragrostis neesii</i> (65); <i>Stipa papposa</i> , <i>Melica violacea</i> , <i>Piptochaetium</i> sp., <i>Andropogon condensatus</i> , <i>Paspalum plicatulum</i> , <i>Andropogon ternatus</i> , <i>Trachypogon montisjari</i> (30).	<i>Axonopus compressus</i> , <i>Paspalum notatum</i> , <i>Andropogon saccharoides</i> , <i>Chloris bahiensis</i> , <i>Agrostis montevidensis</i> , <i>Eragrostis pilosa</i> and <i>E. neesii</i> , <i>Roboelia selloana</i> , <i>Panicum bergii</i> , <i>Setaria</i> sp., <i>Leptocoryphium lanatum</i> (70); <i>Sporobolus poiretii</i> , <i>Andropogon condensatus</i> , <i>Stipa papposa</i> , <i>Andropogon ternatus</i> (25).

Table 3 continued—

Department	Locality	Autumn March—May	Winter June—August	Spring September—November	Summer December—February
Rocha	Cebollati (Uplands)	<i>Paspalum dilatatum</i> , <i>Eragrostis</i> sp., <i>Rotboellia compressa</i> , <i>Axonopus compressus</i> , <i>Chloris</i> sp., <i>Setaria geniculata</i> , <i>Andropogon saccharoides</i> (40); <i>Sporobolus poiretii</i> (40); <i>Adesmia bicolor</i> (5).	Tender grasses, especially <i>Poa annua</i> (35); hard grasses (30); <i>Cerastium glomeratum</i> (10).	<i>Eragrostis bahiensis</i> , <i>Brija minor</i> , <i>Panicum decipiens</i> , <i>Agrostis</i> sp., <i>Stenolaphrum americanum</i> (50); <i>Danthonia ciliata</i> , <i>Sporobolus poiretii</i> (45); <i>Juncus microcephalus</i> ; <i>Adesmia bicolor</i> .	<i>Andropogon saccharoides</i> , <i>Setaria geniculata</i> , <i>Chloris ciliata</i> , <i>Stenolaphrum americanum</i> , <i>Rotboellia compressa</i> (50); hard grasses (20); <i>Cyperus, Juncus</i> (20); <i>Adesmia bicolor</i> (little).
Colonia	Cerro de San Juan	<i>Medicago hispida</i> and <i>M. arabica</i> (40); <i>Setaria caespitosa</i> , <i>Setaria</i> sp., <i>Paspalum notatum</i> , <i>Eragrostis pilosa</i> (30); <i>Sporobolus poiretii</i> (30). (The field in which this plot was situated was formerly a lucerne field.)	<i>Medicago hispida</i> (50 per cent of the area is bare ground).	Hard grasses (30). (In the dry season the plants are short and some cannot be cut); <i>Eryngium nudicaule</i> .	<i>Andropogon saccharoides</i> , <i>Paspalum notatum</i> , <i>Bouteloua megapotamica</i> (30); <i>Andropogon ternatus</i> , <i>Stipa hyalina</i> , <i>Aristida pallens</i> , <i>Pyptochaetium stipoides</i> , <i>Paspalum urvillei</i> (50); <i>Adesmia bicolor</i> , <i>Eryngium nudicaule</i> .
Tacuarembó	Pampa Station	<i>Paspalum dilatatum</i> , <i>Axonopus compressus</i> , <i>Paspalum notatum</i> , <i>Eragrostis virescens</i> and <i>E. neesii</i> , <i>Calamagrostis montevicensis</i> , <i>Andropogon saccharoides</i> and <i>A. ternatus</i> , <i>Setaria caespitosa</i> and <i>S. geniculata</i> , <i>Chloris bahiensis</i> (80); <i>Trifolium polymorphum</i> and <i>Adesmia bicolor</i> (15); <i>Aristida pallens</i> , <i>Sporobolus poiretii</i> (4); <i>Cyperus reflexus</i> , <i>Oxalis</i> .	Tender grasses (75); hard grasses (1); legumes (20).	<i>Paspalum dilatatum</i> , <i>Axonopus compressus</i> , <i>Paspalum notatum</i> , <i>Eragrostis neesii</i> and <i>E. virescens</i> , <i>Setaria caespitosa</i> , <i>Andropogon saccharoides</i> , <i>Setaria geniculata</i> (75); <i>Trifolium polymorphum</i> (20).	
Artigas	Cabellos	<i>Paspalum notatum</i> , <i>Paspalum dilatatum</i> , <i>Chloris bahiensis</i> , <i>Chloris uliginosa</i> , <i>Axonopus compressus</i> , <i>Panicum laxum</i> , <i>Paspalum proliferum</i> , <i>Eragrostis pilosa</i> and <i>E. neesii</i> , <i>Rotboellia compressa</i> , <i>Setaria gracilis</i> , <i>Andropogon saccharoides</i> and <i>A. ternatus</i> , <i>Leptocoryphium lanatum</i> (50); <i>Sporobolus poiretii</i> , <i>Andropogon condensatus</i> and <i>Stipa</i> spp., <i>Andropogon pellitus</i> (25); <i>Trifolium polymorphum</i> , <i>Adesmia bicolor</i> (20); <i>Fimbristylis</i>	Tender grasses (50); hard grasses (25); <i>Trifolium polymorphum</i> , <i>Adesmia bicolor</i> , <i>Vicia graminea</i> .	<i>Andropogon saccharoides</i> and <i>A. ternatus</i> , <i>Chloris bahiensis</i> , <i>Setaria geniculata</i> , <i>Eragrostis bahiensis</i> and <i>E. pilosa</i> , <i>Calamagrostis montevicensis</i> , <i>Rotboellia seloana</i> , <i>Brija triloba</i> , <i>Axonopus compressus</i> , <i>Chloris uliginosa</i> , <i>Bromus erectus</i> (50); <i>Aristida venustula</i> and <i>A. pallens</i> , <i>Paspalum plicatulum</i> , <i>Andropogon condensatus</i> , <i>Stipa</i> spp., <i>Pyptochaetium ovatum</i> and <i>P. stipoides</i> , <i>Sporobolus poiretii</i> , <i>Galactia marginalis</i> , <i>Arachis marginalis</i> .	<i>Paspalum notatum</i> , <i>Axonopus compressus</i> , <i>Eragrostis neesii</i> and <i>E. bahiensis</i> , <i>Andropogon saccharoides</i> and <i>A. ternatus</i> , <i>Setaria geniculata</i> , <i>Leptocoryphium lanatum</i> , <i>Cynodon dactylon</i> (70); <i>Aristida pallens</i> , <i>Sporobolus poiretii</i> , <i>Andropogon condensatus</i> (25); <i>Rhynchosia senna</i> ; several other genera in small proportion.

Department	Locality	Autumn March—May	Winter June—August	Spring September—November	Summer December—February
Treinta y Tres		<i>autumnalis</i> , <i>Baccharis coriifolia</i> , <i>Chaptalia excarpa</i> and <i>C. piloselloides</i> , <i>Verbena gracilis</i> , <i>Sida intermedia</i> , <i>Richardsonia stellaris</i> .			
		<i>Andropogon saccharoides</i> and <i>A. ternatus</i> , <i>Chloris ciliata</i> , <i>Eragrostis neesii</i> and <i>E. bahiensis</i> , <i>Axonopus compressus</i> , <i>Setaria geniculata</i> , <i>Aira caryophylla</i> , <i>Rotboellia compressa</i> (45); <i>Sporobolus poiretii</i> , <i>Paspalum plicatulum</i> , <i>Aristida venusta</i> , <i>Andropogon condensatus</i> and other hard grasses not in flower (45); various weeds (10).	<i>Eragrostis bahiensis</i> and <i>E. neesii</i> , <i>Stenotaphrum americanum</i> and other tender grasses not in flower (40); hard grasses (40); <i>Juncus</i> sp., <i>Polygala tenuis</i> , <i>Polygala linoides</i> , <i>Eryngium nudicaule</i> , <i>Rhynchospora luzuliiformis</i> , <i>Cardamine chenopodiifolia</i> (20).	<i>Axonopus compressus</i> , <i>Briza erecta</i> and <i>B. minor</i> , <i>Andropogon saccharoides</i> and <i>A. ternatus</i> , <i>Eragrostis neesii</i> , <i>Leptocoryphum lanatum</i> , <i>Chloris ciliata</i> , <i>Festuca tenella</i> , <i>Aira caryophylla</i> , <i>Poa lanigera</i> , <i>Briza triloba</i> , <i>Rotboellia selloana</i> , <i>Phalaris angusta</i> (50); <i>Piptochaetium stipoides</i> and <i>P. montevidensis</i> , <i>Andropogon condensatus</i> , <i>Aristida pallens</i> , <i>A. murina</i> and <i>A. venustula</i> , <i>Paspalum plicatulum</i> , <i>Danthonia cirrata</i> and <i>D. montevidensis</i> , <i>Trachypogon montifari</i> (40); <i>Juncus microcephalus</i> , <i>Gnaphaleum purpureum</i> , <i>Sienachaenium campestre</i> , <i>Cyperus reflexus</i> , <i>Buchnera elongata</i> , <i>Rhynchospora luzuliiformis</i> (10).	<i>Andropogon saccharoides</i> , <i>Paspalum notatum</i> and <i>P. plicatulum</i> , <i>Eragrostis neesii</i> and <i>E. bahiensis</i> , <i>Axonopus compressus</i> , <i>Chloris ciliata</i> , <i>Setaria geniculata</i> (50). Hard grasses not in flower, among them <i>Andropogon condensatus</i> (50).

(Spaenberg, Neres, Montedónico, and Fynn, 1941.)

FLORISTIC STUDIES

More recently a short account of the floristic composition of the natural Uruguayan grasslands has been published by B. Rosengurtt (1944), who distinguishes seven types of land, namely, the campos, or virgin grasslands on medium quality soils having no stagnant water and an insignificant quantity of rock, sand, trees and shrubs; the marshlands; former arable lands reverted to grass; rocky and stony lands; woodland swards and halophytic swards. The presence or absence of the various plant species is discussed as affected by the nature of the soil and especially by utilization and management, and the value and uses of the different species and various types of swards are also treated. The photographs illustrating this work, especially those taken vertically at close range, give a clear impression of the different types and particularly of the excellence and close cover of the best swards. (see Pls. 4a and 4b.)

In addition to Rosengurtt's account and to the floristic view of the whole country's grasslands presented in the National Commission's report by Spangenberg and his co-workers, a picture of a more restricted area in the Department of Cerro Largo, north-eastern Uruguay, has emanated from some thorough investigational work done by a group of young scientists (Gallinal, Bergalli Soñora, Campal Gómez, Aragone Leonardi, and Rosengurtt; 1938, 1939 and 1943). The area studied is the Palleros Estancia or ranch, 111 square kilometres in extent, in a region where cattle are reared rather than fattened, the southern part of Uruguay being more suitable for the latter purpose. On the basis of a careful botanical study of these lands, illustrated by a large number of excellent photographs, conclusions for grassland management and improvement under the regional conditions have been reached. (See Pls. 2a, 2b, 3a and 3b.)

PRODUCTIVITY OF THE URUGUAYAN GRASSLANDS

Returning to the National Commission's report, Spangenberg and collaborators recorded the following average yields (figures given in quintals* per hectare): green weight 138.9 ± 21.9 (mean error); hay, 45.5 ± 4.3 (mean error); (figures which are approximated by those obtained for the Palleros area by Gallinal and collaborators in 1938, namely, 135.6 and 63.1 respectively). Production is higher in autumn than in spring, but both seasons are those of abundant grass growth, as is shown by the following synopsis of mean seasonal production per hectare, both of green weight and hay, in percentage of the total annual yield:

				Autumn :	Winter :	Spring :	Summer :
				March to	June to	Sept. to	Dec. to
				May	August	Nov.	Feb.
Green weight	...	...	...	40.5	20.8	26.7	12.0
Hay	...	...	...	38.5	15.8	31.1	14.6

The figures given for mean seasonal rainfall and temperature are as follows:

				Autumn :	Winter :	Spring :	Summer :
				March to	June to	Sept. to	Dec. to
				May	August	Nov.	Feb.
Rainfall (in mm.)...	...	...	...	348.8	231.1	227.4	246.7
Temperature	...	...	...	17° C.	11.8° C.	15.6° C.	21.1° C.

Shortage of fodder can easily occur in the summer and in the winter.

* 1 quintal=100 kg.

SOIL SURVEY

Not only has the herbage of the country been surveyed by the Commission, but a systematic study of the soils has been made from a network of observational centres (*Herb. Rev.* 1940) so that it has been possible to determine the correlations existing between the nutritive value of the grasslands and the quality of the land. Statistical study of the soil analyses and the herbage of the twenty-three representative plots showed the importance of good physical constitution in soil in relation to varying content of certain elements such as calcium or phosphoric acid. Positive correlations were found to exist between production of hay and the following soil constituents respectively: humus, calcium, phosphoric acid. There was a positive correlation also between production and the ecological factors rainfall and humus. The impression was obtained that variation in humus content had more effect in determining the amount of yield than differences in calcium and phosphoric acid content.

The quarterly cuts from the twenty-three plots were analysed for total protein, pure protein, fat, cellulose, ash, calcium and phosphoric acid. The figures for the different plots, in grm. per 100 grm. dry matter, are presented (a) for the different seasons, (b) for the year. From the table showing the seasonal figures obtained it appears that the protein, calcium and phosphorus content of the herbage was lower in the summer and spring than in the winter and autumn, but it is noted that these results are in general a consequence of the more advanced state of vegetation of the plants cut in December and March, when many herbage species have just finished growing.

It was a striking fact that the most productive grasslands were, on the whole, those yielding the most nutritive herbage. Positive correlations (over 99 per cent accuracy) were found to exist between the following constituents of herbage and soil respectively:

Herbage		Soil
Total protein	:	Humus
Calcium	:	Calcium
Phosphoric acid	:	Phosphoric acid

In general the most fertile lands contained valuable grasses such as *Lolium multiflorum* and *Bromus catharticus*, and were those also which produced herbage with the highest protein content.

LEGUMES

The presence of legumes, especially *Medicago arabica* var. *maculata* and *M. hispida* var. *denticulata*, of sub-spontaneous character, was determined in good proportions on the ranches of the southern part of the country. In the north, although the above-named legumes were not found to any appreciable extent, there was a good proportion of indigenous legumes, *Trifolium polymorphum* and *Adesmia* spp., in the plots located in soils on basalt formation. The presence of legumes entailed in every case a higher content of calcium and phosphorus in the herbage, the plots deficient in legumes having herbage deficient in these minerals. The legume-deficient plots were always found in land of certain geological formations. Not only were plots in calcium and phosphorus-deficient land lacking in legumes, but they were also distinguished by a larger proportion of coarse grasses such as *Andropogon condensatus* and similar species.

REGIONAL CHARACTERISTICS

Commenting on the regional characteristics of the different natural grazings, the Commission's report notes that the best or fattening pastures are found to coincide with a higher degree of soil fertility; in the poor campos carrying capacity and the percentage procreation are both low. In campos of medium fertility, as for example in the Departments of Flores, Durazno, and Colonia,

there are exceptions on account of a high degree of good management. Where there is a greater subdivision of grazings and a certain amount of rotational grazing is possible, an improvement is seen at once in the chemical composition of the herbage (higher protein and lower cellulose content), in carrying capacity and in percentage procreation, even although the fertility of the land is by no means outstanding.

SOIL DEGRADATION

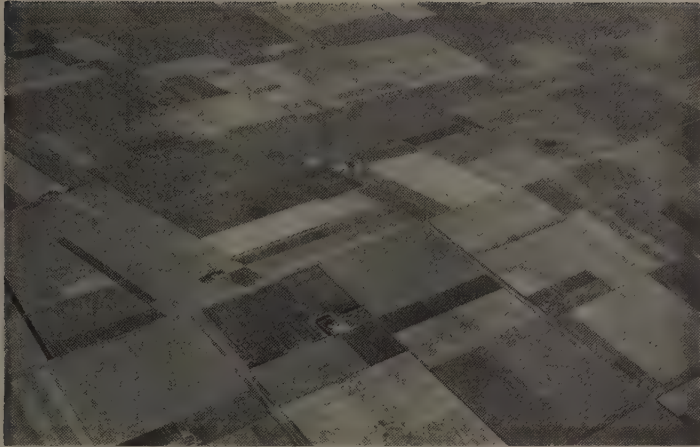
From the Commission's report it is evident that the deterioration of the Uruguayan grasslands lies not only in its botanical deterioration, but in soil degradation also. Boerger writes: "A further contribution to the deterioration of the sward is made by the recently discovered impoverishment of the soils in lime phosphates. . . . It is not only that there has been—since the Spanish conquerors four centuries ago introduced European domestic animals—a continual withdrawal of the mineral substances requisite for the skeleton structure of the land, without the making of any corresponding restoration, but there has also been an intensification of this process through the exporting of dried meat begun early in the nineteenth century." There is a continuous increase of osteomalacia in the phosphate-deficient regions, where the fertility index in cattle may be reduced to 30 or 40 per cent as against 80 to 90 per cent on good pasture land. (Boerger, 1938a.)

IMPROVEMENT

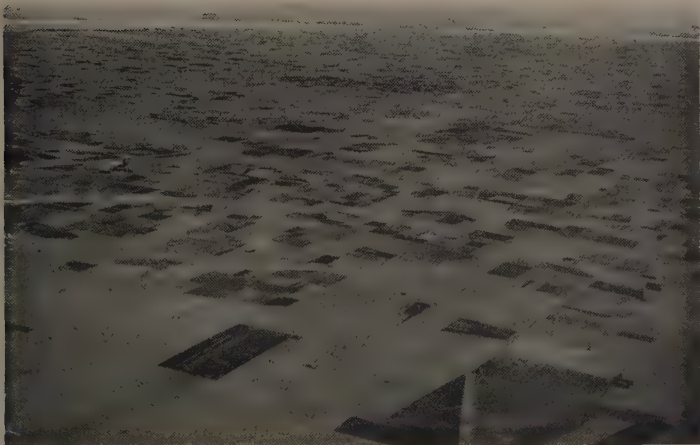
The Commission's immediate tasks, then, consist in determining measures for the improvement of the natural grasslands, in solving the protein problem, the mineral deficiency problem, the problem of seasonal shortage, and in discussing questions such as the value of intensive versus extensive farming, the encouragement of temporary leys on ploughed land, and others which have been enumerated elsewhere. (Boerger, 1939a, 1939b, 1940. *Herb. Rev.* 1936, 1940.) Supplementary work includes the study of weeds and toxic plants, and certain entomological problems. The cattle tick does not appear to constitute a serious pest in Uruguay, although bathing against tick is practised; but, of insects attacking plants, *Toxoptera graminum*, a pest of serious menace to winter leys of fodder cereals, is receiving attention, as are also the periodic invasions of locusts to which the western and, to a somewhat lower degree, the central region is prone. (Spangenberg and Henry, 1938.) "These are surface feeders which defoliate everything in their path, leaving no trace of green vegetation." (Davies, 1940, p. 38.)

In reference to the improvement of the natural grasslands, Spangenberg considers that no technical or economic purpose is served by destroying the existing plant stands. The natural sward should be maintained as far as possible intact, supplementary seeding being accomplished in furrows more or less widely spaced, in accordance with the species to be sown, or in land scratched up by harrows. For this purpose, *Lolium multiflorum* and *Bromus catharticus*, sown at the end of summer, are specially recommended. Seed of the indigenous herbage plants should be grown in the locality of the improvements, within good, fenced pastures. (Spangenberg, 1936.) Manurial treatment is considered unprofitable under Uruguayan conditions. (Boerger, 1935.) In connexion with improvement, Spangenberg and collaborators make an interesting comparison of conditions in Uruguay with those in New Zealand. Drawing attention to the practice of "surface sowing", or scattering seed without the usual preliminary preparation, in New Zealand, they give the following figures:

	Uruguay	New Zealand
	Hectares	Hectares
Natural grazings	15,500,000	5,866,700
Surface sowings	—	4,450,600
Pasture in arable land zones	300,000 to 500,000	2,427,600



PL. 1a. ARGENTINA. The humid pampa. Flat plain 65 miles west south-west of Rosario. Vague, trail-like markings may be seen crossing the fields. (*Photograph by J. L. RICH. 1942. Courtesy of American Geographical Society*)



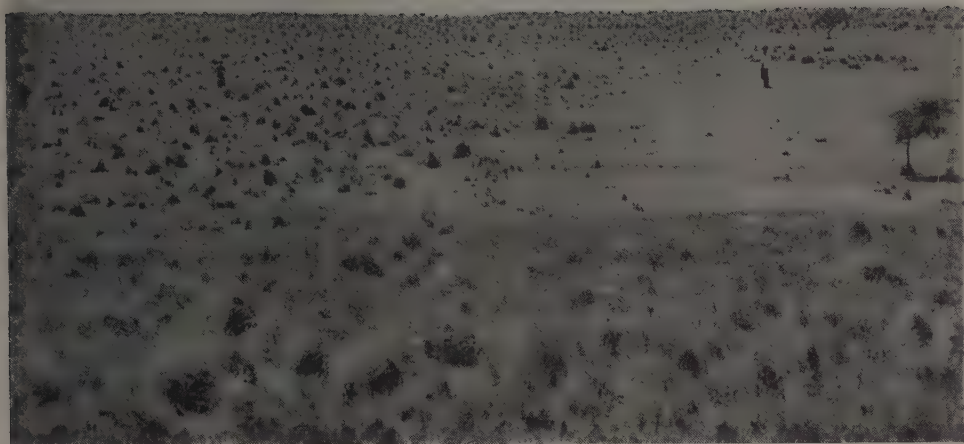
PL. 1b. ARGENTINA, PROVINCE OF ENTRE RÍOS. The plains of northern Entre Ríos, about 50 miles north of Concordia, showing the rich black soils and the numerous watercourses. (*Photograph by J. L. RICH. 1942. Courtesy of American Geographical Society*)



PL. 2a. NORTH-EASTERN URUGUAY. Unimproved area with *Erianthus trinii* covering slopes and ridges. In the foreground, short sward continuously grazed while *E. trinii* remains intact. *Baccharis trimera*, *B. coridifolia*, and *Eryngium paniculatum*, frequently associated with this type of grassland, are not shown. (Photograph by B. ROSENGURTT. 1938)



PL. 2b. The same area as above, four years later, after cutting.
(Photograph by B. ROSENGURTT. 1943)



PL. 3a. NORTH-EASTERN URUGUAY. Unimproved tall grass area covered with *Erianthus trinitis*, with transition to short sward, centre right. (Photograph by B. ROSENGURTT. 1938)



PL. 3b. The same area as above, four years later, after cutting. Stock in the background entering for the first time. (Photograph by B. ROSENGURTT. 1943)



PL. 4a. URUGUAY. Virgin grassland of the granite region. The sward is composed almost entirely of useful species. *Mercurialis perfoliata*, *Leucanthemum lachnoides*, *Raphanistrum selleana*, and a loose and grazed form of *Stipa charruana*. The worthless species are *Spilanthes decumbens*, *Hypochaeris* sp., and *Scutellaria racemosa*. *Festuca australis* and *Oxalis bipartita* are found in the interstices without being aggressive. (Photograph by B. ROSENGURTT. 1944)



PL. 4b. NORTH-EASTERN URUGUAY. The normal sward of the Palleros grasslands in the Department of Cerro Largo. *Paspalum notatum* and *Axonopus compressus* are closely intermingled. Associated species are *Trifolium polymorphum*, *Piptochaetium panicoides* in loose and scattered tufts, *Oxalis macracris* and *Chaptalia exscapa*. (Photograph by B. ROSENGURTT. 1943)

They consider that while surface sowing is no doubt suitable under New Zealand conditions and in the special circumstances in which it is employed, cases in which it might be useful in Uruguay are very limited. The difference in the two countries' areas of pasture in arable land, however, is found to be interesting. Although the severer winter of New Zealand makes the growing of special forage crops a more urgent matter there than in Uruguay, yet there are various reasons which make increasing ley cultivation desirable in Uruguay.

LUCERNE UNSUCCESSFUL IN URUGUAY

It has already been noted that the lucerne ley of Argentine type is seen only exceptionally in Uruguay, the reason being that serious difficulties in growing lucerne are encountered, principally because of the country's compact soils with impermeable subsoil. (Boerger, 1939*a*, 1939*b*.) While it continues to be the most important cultivated legume, the temporary ley of forage oats, generally grazed, of green maize, of grasses such as Sudan grass (*Sorghum sudanense*), Rhodes grass (*Chloris gayana*), elephant grass (*Pennisetum purpureum*) and of various kinds of sorghum has become increasingly common on certain types of Uruguayan ranch: the oats area alone increased from 426 hectares in 1901-05 to 78,085 in 1934. (Boerger, 1937*a*.)

HERBAGE LEYS

Boerger and his school are conscious of the necessity for discovering a form of ley that shall consist of or include legumes and shall yet be capable of successful cultivation under such Uruguayan conditions as are unsuitable for lucerne. "The difficulties confronting a wider distribution of lucerne, which gives such good results in Argentina, are well known. And even more difficult is the cultivation of the *Trifolium* species which in colder countries represent the great natural source of protein. Happily in some parts relatively large, spontaneous fields of legumes are formed in the cold season by two species of *Medicago*, *M. denticulata* and *M. maculata*. There should be mentioned also *Adesmia bicolor*, an indigenous legume growing wild in some parts of the country, and some other legume species found sporadically in the natural grazings. But the growth of even the most widespread legume species is limited to certain regions, and their practical value is still more reduced by their relatively short period of growth. There undoubtedly exists, then, a shortage, and at times an actual absence of proteins for animal nutrition. This deficiency, especially accentuated at certain seasons, is the aspect of the national forage problem which is in most urgent need of solution." (Boerger, 1939*b*.) It is considered that the La Plata lands offer very favourable opportunities for the conservation and improvement of soil fertility merely through the application of a well-studied rotation. (Boerger, 1939*a*.) "Of the 9 million hectares considered suitable for tillage, when the area actually destined for this purpose is deducted there yet remains an ample margin which could be used to reinforce, with reserves of hay and silage, the country's supplies of fodder." (Spangenberg and collaborators, 1941.)

At the same time, attention is drawn by Boerger to the limitations at present imposed by natural and economic conditions on the practice of rotational cropping in a country such as Uruguay. The area devoted to arable and mixed farming, including the growing of forage crops, is approximately 1.5 million hectares, whereas that occupied by the "extensive" system of grazing cattle over large areas of natural grassland is approximately 15 million hectares. (Boerger, 1937*a*.) "When all is said and done, and even under the present and probably the future trend towards a more intensified form of animal husbandry, the natural pasture will always play a part of transcendent importance in Uruguay." (Spangenberg and collaborators, 1941.)

Since the above was written, a three-volume work on agriculture and agricultural research and improvement in the La Plata region, comprising Uruguay, a large part of Argentina, and

most part engaged in agriculture or stock raising of a nature determined by the very diverse environmental conditions.

CLIMATE AND TOPOGRAPHY

The south of Brazil has certain characteristics which make a sharp cleavage with the states lying to the north. The region comprises the three states of Paraná, Santa Catarina and Rio Grande do Sul, situated the one above the other from north to south. At the juncture of the states of São Paulo and Paraná there is an important boundary between the rainfall system common in the highlands of tropical Brazil, where a winter dry season occurs, and the southern rainfall system with rain all the year round. A fairly sharp line running a little south of the town of Sorocaba (23°31' S. and 47°29' W.) divides the two zones. At approximately the same latitude, also, is found an important temperature boundary, namely, the northern limit of frosts. Frosts are common in the uplands of Paraná, where freezing temperatures are experienced every winter, although they do not occur along the coast nor in the valley of the river Paraná and its deeper tributaries. The river Paraná on the west forms a sharp vegetation boundary to the south Brazilian grasslands, for immediately west of it begins scrub forest with open patches of savannah. On the east the great forest-covered escarpment separates the upland prairies from the coastal lands.

As far as surface features are concerned, very similar country is found north and south of the border of São Paulo, but the change in climate is reflected in a change in the natural plant cover. From Sorocaba southwards there is a gradual transition from tropical semi-deciduous forest to pure grassland, the prairies which occur in patches throughout southern São Paulo, Paraná and Santa Catarina becoming more extensive than the forests in Rio Grande do Sul south of the Uruguay valley. (James, 1941.) In the Uruguayan frontier region tree growth is practically absent, even by the watercourses, except for artificial plantations. (Domingues, 1941.) "This is a region of plentiful rainfall, in which the prevalence of grass instead of forest has never been adequately explained", writes James (1941, p. 517), but notes that grassland and forest distribution are closely related to the underlying rock formations.

The relatively temperate climate (Köppen symbol *Cfa*), frosts which ensure a greater freedom from ticks and insect pests, and wide, free ranges of natural herbage make this region one eminently suited for pastoral activities, its value improving towards the south. In an interesting classification of the pastoral regions of Brazil Domingues (1941*b*) treats the three southernmost states as two regions, which he calls the "south" and the "frontier" regions, a division certainly justified by the superiority of the latter. Of the so-called south region, or the states of Paraná and Santa Catarina plus the hill lands of Rio Grande do Sul, the grazings comprise partly natural range lands and partly prepared pastures on arable land that was originally forest. These grazings, interspersed among forests and cultivated lands, are mostly on high ground, flat or more or less undulating, and the pastures prepared on arable land are frequently better in quality than the natural grazings. (Fig. 11.)

PASTORAL INDUSTRY

Of Domingues' "frontier" region, however, or the extreme south of the Rio Grande do Sul state, the pastures are all natural, in general very flat or slightly undulating and composed entirely of herbaceous plants. The absence of tree growth has already been noted, and the general aspect of the region is that of a grass prairie, the monotony of which is relieved only by occasional *Eucalyptus* groves that have been planted. The appearance of these grasslands thus bears a closer resemblance to the humid pampa of Argentina than to the neighbouring Uruguayan lands with their forest-ribboned river courses. Although the frontier pastoral region is the smallest in extent

of all the seven into which Domingues classifies Brazil, it is by far the most important. Its flocks and herds are the most valuable to be found in the country and are composed almost entirely of valuable breeds. (Domingues, 1941*b*.) The best beef cattle in Brazil are reared here, namely (in order of the numbers recorded), Herefords, Durham Shorthorns, Polled Angus, and Devons. As in Argentina and Uruguay, animals can be kept in the open throughout the year. Rainfall



FIG. 11. PASTORAL REGIONS OF BRAZIL. *After O. DOMINGUES*

is in general sufficiently frequent to maintain the grazings in good condition ; the summers are hot and the winters cold, but there are no extremes of temperature, and watercourses are abundant. The importance of Rio Grande do Sul as a stock-raising state is seen from the fact that, of a total of forty million cattle recorded for the twenty-three states which make up Brazil, over ten million—and those high-grade animals—are registered for this state alone. There are four meat chilling and packing factories in the state, two preparing meat for export, two for internal consumption, and the establishment of more is contemplated. (Brito, 1939.)

In Paraná and Santa Catarina, while conditions and herbage, the quality of the animals and grazing technique are on the whole good, there lack large, uninterrupted areas of natural range lands, and the livestock industry is less developed. A more diversified type of farming including dairying is, however, making considerable strides in these states and in certain parts of Rio Grande do Sul, a trend which is largely due—as in Uruguay and elsewhere—to the influence of European immigrants. The number of cattle recorded for Paraná and Santa Catarina respectively is 500 thousand and 680 thousand. (Brito, 1939.)

FLORA OF RIO GRANDE DO SUL

In 1900 C. A. M. Lindman published in Sweden a detailed floristic study of the State of Rio Grande do Sul, based on his own explorations. The greater part of this work is devoted to the campos, according to Lindman's map the largest of the three divisions (coastal lands, campos, and woodlands) into which the plant cover of the State falls. Lindman prefers the word "campo" to any other for the lands which in this bulletin are described as grasslands. "Under the comprehensive term 'campo'", he writes, "South Americans understand all land that is not wooded, irrespective of terrain and plant cover. . . . If the country people in any way limit the universal description 'campo', it is merely in regard to the serviceability or otherwise of any area as a grazing, and the only place totally useless for this purpose is forest." Lindman is impressed by the monotony of the Brazilian campos, as Hauman (1925) is by that of the Patagonian steppe. "Those who know only the vegetation of Europe and the great diversity of its plant environments and formations . . . can hardly form an idea of the homogeneous and monotonous aspect of Nature over large areas of South America. Similar physical conditions prevail over immense stretches of land with which in our part of the world only the Russian steppes are comparable. Accordingly the vegetation also, although its great abundance of species might cause one to expect a very varied type, is composed of only a few plant formations which the traveller finds repeated day after day with unchanging uniformity, to an extent often to be measured in degrees of latitude and longitude."

Lindman's tour led him from the coast along the river Jacuhy and northwards, not along the southern frontier region where the best pastures appear to be situated. Perhaps, however, his account of the campos near the town of Cachoeira, which is situated at an altitude of 102 metres on the Jacuhy and approximately in the middle of the State of Rio Grande do Sul, may be taken as more or less typical of the grasslands of that State. The town is surrounded by gently undulating or perfectly flat grassy lands, bounded 100 km. to the south and 50 km. to the north by ranges of hills, but extending east and west without interruption, except for some woodland along the shores of the river, as far as the eye can reach. The undulating lands look as if comprised of large separate plots, having a slightly convex surface and outlined by a narrow belt of woodland or close thicket along the deepest, more or less humid parts of the depressions. (Comparison is made here with the rolling prairies of North America and the moist depressions, named "swales" or "sloughs", found in them.) Here and there the land is intersected by gullies or stream-beds, several metres deep, with sides cut steeply into the red clay soil and with a mere trickle of water at the bottom in summer. Lindman's illustration of these gullies shows no protective plant cover such as the tree growth found by the river or the thicket of the swales.

The plant cover of the campos is on the whole close and even, the red clay soil being visible only on the edge of the gullies. The vegetation consists predominantly of grasses. Although it was at the end of summer when Lindman visited the region, the campos everywhere looked fresh and green. In the immediate vicinity of the town, where there are scattered farms, the herbage is close, tender and luxuriant, an improved type produced under grazing, treading, and

manuring, and is comprised largely of short, perennial grasses of which *Paspalum notatum* is the most important. Other components, also short and with tender leaves, are *Paspalum sanguinale*, *P. platycaule*, *P. furcatum*, *P. mandiocanum*, *Eleusine indica*, species of *Cyperus* and *Kyllinga*, and small-leaved species of the Leguminosae. Further from the town and at some distance from roads and tracks, in places untouched by traffic, such as small eminences or slopes, the same low-growing formation is often varied by a greater admixture of low-growing plants with bright flowers, and is thus transformed into a heath. Among the components mentioned are the legumes *Zornia diphylla*, *Stylosanthes guianensis*, and *Acuan virgata*, together with *Calydorea campestris*, *Ionidium bicolor*, species of *Polygala*, *Cuphea*, *Oxalis*, *Baccharis*, *Chaptalia*, etc. There may also be scattered individual plants or half-shrubs attaining a greater height, say, 0.5 to 0.7 m., such as species of *Macrosiphonia*, *Baccharis genistelloides* and others. Again, from these short grass swards and flowery heaths attention is drawn to another parallel formation, a tall, bunchgrass community which also occupies large areas. The two dissimilar formations, the one only 1 to 2 dm., the other 1 to 2 metres in height, exist side by side with sharply defined boundaries, or else the one constitutes small patches within the wide-spread stands of the other. The most striking components of the tall-grass formation are species of the Andropogoneae. Some of these form tufts having great quantities of long, often striped leaves; examples are *Elyonurus latiflorus*, with fine leaves fluttering in the wind, and *Erianthus angustifolius* with coarse and stiff, recurved leaves. Others again are more evenly distributed, almost as if sown in a field, the most common, perhaps, being the red-haulmed *Andropogon incanus*. *A. spathiflorus* and *A. condensatus* are also found in this formation, although not so abundantly as in the woodland regions or highlands. Such parts of the tall-grass formation in which *Aristida* and similar grasses are dominant have a desolate, impoverished aspect. These grasses, approximately 50 cm. in height, are distinguished by thin straw, narrow, rolled leaves and much earlier maturity than *Andropogon*: those noted near Cachoeira are *Aristida pallens*, *A. complanata*, *Trachypogon polymorphus*, and also *Elyonurus latiflorus*. Before the summer is far spent such swards burn readily, and in the autumn they are useless for grazing while the *Paspalum* swards are still fresh and green and the *Erianthus* and *Andropogon* types also are still vigorously growing. Yet another variation is seen towards the later part of the growth period, when the tall-grass formation in some places is modified or replaced by a rich association of tall herbaceous plants with bright flowers. (Lindman, 1900.)

Abundant information on the individual plants is available in the great Brazilian floras, Martius, Eichler and Urban's "Flora brasiliensis" (1840-1906) and Pio Corrêa's "Dictionary of Brazilian plants" (1926-31). Brito (1939) describes the natural herbage of Rio Grande do Sul as excellent, with a nutritive value adequate for the more exacting requirements of the type of animal sought by the meat chilling factories. The herbage of the frontier zone, he writes, resembles that of Uruguay. Domingues (1941b) mentions the genera *Paspalum* and *Axonopus* as important components of the grasslands of his "south" region, together with legumes of the genera *Trifolium*, *Adesmia*, etc. Of the herbage of the frontier region he, with Brito, says that it is "excellent, favoured by a suitable climate and a rich soil in most cases". He mentions as the most frequent plants here *Stipa neesiana*, *Paspalum distichum*, *Poa annua*, *Digitaria sanguinalis*, *Briza* spp., and several species of *Trifolium*, without, however, naming the clover species. Plants collected by Alfred Bornmueller in Rio Grande do Sul from 1903 to 1907 included thirteen grasses and a surprisingly large number of legumes, not all of which belong, however, to the natural grazings. (J. Bornmueller, 1934.) In a systematic study of the genus *Lathyrus* as found in Rio Grande do Sul (1936a) Malme notes that the infrequency of *Lathyrus* species is probably due to their palatability to stock, which endangers their existence. The northern limit of the genus in Brazil is believed to be in the state of Paraná. Dutra (1938), writing on the bamboos of Rio

Grande do Sul, notes that some species, including *Chusquea meyeriana*, are considered to be good forage plants.

Valuable fundamental studies of the herbage and forage plants of southern Brazil have been published from time to time by Avila de Araujo (1935, 1936, 1938, 1939*a*, 1939*b*, 1940*a*, 1940*b*, 1943).

Even in this region there is a shortage of feed in the winter season, attributed to the paralysing action of lower temperatures, frost and continuous cold winds on plant growth. The average annual loss occasioned thereby is estimated as 6 per cent. Lucerne leys of the Argentine pattern being unsuccessful here, haymaking from plantings of oats or ryegrass, or—more economically—from areas of the natural herbage, fenced off in July for cutting in February or March, is suggested by a Government official as one solution. Another solution is ensilage, and a final solution is improvement, based on agrostological research. For this purpose the State Government is installing an Experiment Station at São Gabriel, and the Federal Government has already initiated experimental work at the Bagé Experiment Farm. (Rocha, 1943.)

DEVELOPMENT OF ANIMAL INDUSTRY

While it is believed that, in general, the floristic composition of the herbage of southern Brazil and more particularly of the frontier region resembles that of Uruguay to a considerable extent, there is nothing to show exactly what modifications have taken or are taking place as a result of the biotic factor. The history of stock raising in this region is not unlike that of Brazil's southern neighbours. Cattle were introduced by the Portuguese in the first half of the sixteenth century, and the roving companies of armed adventurers—generally referred to as the “bands”—who in the colonial days penetrated far into the interior of Brazil accompanied by their herds of cattle, pushed also from the town of São Paulo down through the grassland regions of the south as far as the shores of the Rio Plata. Many of these adventurers, who had originally set out to find gold and precious stones, stayed behind to claim for themselves pastoral property in the rich grasslands of the south, where they reared and traded in cattle, horses and mules. They remained in the central highlands of the southern region, the forest of the escarpment zone remaining an effective barrier between them and other colonists who had pushed along the coast. Cattle were driven overland to the great trading centres further north, Sorocaba, where an annual fair was held, being especially important in this connexion.

Stock raising has remained the staple industry of the region. From 1715 onwards the “jerked” (salted and sun-dried) beef industry came to the fore; eighteen factories were functioning in this region in 1820 and the exporting of jerked beef as well as tallow and other meat products had already begun in 1805. It was not until 1912 that the first chilling plant was established in Brazil, but a great impetus was given during the war of 1914-17 to this branch of the industry, which reached a peak in 1930, when 112 thousand tons of meat (figures for the whole of Brazil) were exported. (Brito, 1939. James, 1941.) Nevertheless, Brazil's exports of meat do not exceed 9 per cent of the total for South America, other commodities such as coffee, cotton and cacao holding a more prominent position in her trade with the outer world, and in spite of the large amount of meat raised for home consumption it is doubtful if the exploitation of the south Brazilian grasslands has been as intensive as that, for instance, of the Argentine pampa. At the same time the increasing emphasis on the chilled meat export trade involves the carrying off of bone and other plant foods without replenishment, since no manuring is practised, wherein a certain degradation of the land is entailed. And it has been pointed out by James (1941, p. 522) that a certain amount of erosion has been produced on the old cattle trails, where “the feet of countless animals have cut paths on the valley slopes which have led to the formation of gullies”.

The temporary ley of oats, rye, lucerne and different clovers for supplying extra fodder is already seen in the frontier region (Domingues, 1941*b*), but it is doubtful if mixed farming will ever develop to any appreciable extent in this region. The stock raisers of the central southern grasslands are predominantly the original Portuguese Brazilians, the agriculturists of the southern States are the European (German, Italian and Swiss) immigrants, and a fusion of the two ways of life seems at present improbable. That development of some sort is likely to occur, however, is to be expected both from the far-seeing and energetic organization of agricultural research and education now in progress under the direction of the Brazilian Government, and also from the unusually vigorous nature of the inhabitants of this region, where the population is increasing at the rate of 23.9 per thousand per year.

TYPE 1. GOOD NATURAL GRASSLANDS

(*d*) Part of Entre Ríos, Argentina

In addition to the foregoing, mention may perhaps be made of one of two borderline examples.

The Argentine province of Entre Ríos, situated (as its name suggests) between two great rivers, the Uruguay on the east and the Paraná on the west, is omitted by Parodi from the humid pampa area (see Fig. 7) and appears to form a transition region. It covers an area of some seventy-six thousand square kilometres and in general physiognomy shares the characteristics of the neighbouring provinces of Buenos Aires, of Santa Fé and Corrientes on the west and north, and of the neighbouring countries of Uruguay and southern Brazil on the east. The soil is the fertile black earth (Hardy, 1942); Rich (1942) describes it as being "almost jet-black", as seen from an aeroplane, all the way across Entre Ríos and in Corrientes. This productive land, mostly flat or slightly rolling, is much used for cultivation, especially of grain, and Rich's aerial photographs show the breaking up of the natural pasture in varying degrees of completeness, some large areas being practically untouched, others divided into rectangles and almost entirely cultivated. (Rich, 1942, Figs. 143, 144 and 145.) (See Pl. 1*b*.)

REGIONAL DIVISION

Baez (1944) has recently published an interesting account of the province's grasslands. He distinguishes, on the basis of their floristic characters, four geobotanical regions, as follows: (i) The Montiel woodland region or "monte", comprising open woodland, *Prosopis nandubey* and other woody Mimosoideae dominant, mixed with *Trithrinax campestris*. These woodlands occupy the central north-western quarter of the province. A photograph in Baez' article shows the trees to be widely spaced, with a close herbaceous sward between them. (ii) The Entre Ríos grasslands proper, consisting of undulating plain with few indigenous trees but interspersed with islands of shrubs where the land is not cultivated. These lands in their natural condition appear to be a continuation of the undulating grasslands of Uruguay and southern Brazil, but, as already noted, they have been greatly modified and cut up by agricultural activities. (iii) the Paraná Delta region. This region consists of approximately a million hectares, extending north as far as the town of Diamante. It is liable to flooding and the vegetation is of a marsh type, but its forage reserves are important at all times of the year. (iv) Finally there is the region of the two great rivers. Dense forest of Brazilian and Chaco-Paraguay origin fringes the river Paraná as far as the Delta, and forest—having components many of which emanate from southern Brazil—fringes the river Uruguay also.

From the forage viewpoint two classes of land are distinguishable, namely, the uplands with firm soil, comprising the greater part of the province or 6,279,336 hectares, and the lowlands of islands and marsh, the altitude of which ranges from 0 to 20 metres above sea level. (See Fig. 12.) Practically all grazing is carried out in the uplands, but the Delta and island lowlands furnish an



FIG. 12. PROVINCE OF ENTRE RÍOS, ARGENTINA
Map adapted by M. E. EDWARDS

The heavy line is the elevation of approximately 20 metres which separates the lowlands of the south and east from the uplands of the centre and north.

The hatched section indicates the zone of seed-propagated grasses or annuals and the white section that of root-propagated grasses or perennials.

- Hg = Hard grasses.
- Sg = Strong grasses.
- Cg = Cultivated or better grasses.
- Wg = Water grasses.

After J. R. Baez. *Rev. argent. Agron.* 11. 129-42, 1944.

invaluable reserve at times of drought or locust invasion. The forage plant cover depends less on the climate (Köppen's *Cfa*) than on the topography, whether upland or lowland, and very particularly on the action of man.

THE NATURAL GRASSLANDS

It is difficult to find a district in the province where the herbaceous vegetation is found in its natural or virgin state, unmixed with invading or foreign plants. *Anthemis cotula* and *Cynodon dactylon* are found in the most hidden corners of the Delta and in the most remote parts of the Montiel, and wherever a furrow is ploughed invading species appear as if by magic, nearly always beginning with the Compositae (*Carduus* species, *Centaurea melitensis*, *Xanthium spinosum*); then the Cruciferae (mustards, *Brassica* spp.); Umbelliferae (*Ammi visnaga* and *Conium*

maculatum), and many others which indicate that the seeds are already scattered throughout the campos, only awaiting ploughing for germination.

Nevertheless, in some places where the land has not been much stocked there are still found almost virgin natural grasslands, that is to say, composed for the most part of indigenous, semi-hard grasses, although *Paspalum* and *Axonopus* are found in all the sandy and humid lands, being very frequent on the shores of the river Uruguay and a fundamental component of the Uruguayan grasslands.

These natural grasslands are obviously of advantage to the grazier on account of their topographical and climatic characteristics. On all farms where there are still unploughed lands it is considered advisable by Baez to fence off an area for the use of cattle during the critical seasons of drought or of bad weather (thunderstorms with heavy rainfall). For it is very common to neglect this important precaution. In the rainy seasons animals seek the high and hard places, free of mud, for grazing and sleeping, and in the dry periods the only resistant grasses which remain are species of *Stipa*, *Melica*, *Andropogon*, etc. These grasses, in spite of their only mediocre forage value and their generally poor bulk, are the salvation especially of the cattle under the circumstances mentioned: the animals maintain their existence with the hard tufts which they uproot intact, then reject the fibres and eat the most tender parts.

HARD GRASSES

Four types of grasses are distinguished, as follows: (a) The hard grasses. These are the types which prevail in the natural grasslands and consist of *Stipa brachychaeta* (most frequent in the Paraná basin) and other species of *Stipa*, *Melica macra*, *Piptochaetium* spp., *Panicum bergii*, which is widely disseminated and grows in old arable land in association with *Echinochloa colona* and *Digitaria sanguinalis*, and various species of *Setaria*. It is noted by Baez that although there are hard grasses in Entre Ríos, there are no actual hard grass areas, for the species listed above are always intermingled with tender grasses, and among the tufts of the hard grasses may be seen colonies of *Medicago hispida* var. *denticulata*, *Erodium malacoides*, *Oxalis articulata* and numerous tender grasses such as *Bromus catharticus* and species of *Lolium*, *Hordeum* and *Poa*.

A zone where hard grasses, although not so tall, are preponderant is the plain which extends from the Department of Colón to the north-west as far as the river Feliciano on the north, and to the east as far as the junction of the province of Corrientes and the river Uruguay. These grasslands are interesting on account of their decorative appearance in the spring, for bearded grasses (*Aristida*) predominate and grasses which give a reddish and bluish tinge such as *Melica*, *Bouteloua*, *Briza*, etc.; the former are so abundant that they form a uniform carpet which looks like an artificial and very carefully kept park.

In the summer and autumn, in the districts of the north close to Corrientes, there abound three or four species of *Andropogon*, especially *A. condensatus* and *A. consanguineus*, and in the humid depressions enormous tufts of *Panicum prionitis* and other allied plants, to which are added various species of *Paspalum* and the unfailing Chlorideae of the uplands.

STRONG GRASSES

(b) The strong grasses. Among the strong grasses must be grouped certainly the greater part of the indigenous species of the virgin grasslands of Entre Ríos, before man had modified the herbaceous growth by the introduction of cattle and by tillage. Parodi (1930) attributes the expression "strong" grasses to the consistency given them by the narrow leaves, convolute and rich in collenchyma.

When spring sets in, in lands that have not been stocked with cattle there appears a cover of semi-tender grasses alternating with nutritive legumes (*Trifolium* spp. *Lathyrus silvestris*, *Medicago hispida* var. *denticulata*). Among the grasses *Stipa* and *Piptochaetium* species are unfailing, as well as *Poa*, *Hordeum* and *Briza* spp. and an innumerable quantity of others which escape the inexpert. To the group of strong grasses may be added also *Andropogon saccharoides*, *Elyonurus* and *Rottboellia*, *Stipa hyalina*, *S. neesiana*, *S. charruana*, *Eragrostis* spp., all frequent, and species of *Paspalum*.

TENDER GRASSES

(c) The tender grasses. These grasses are disseminated around human dwelling-places or in much-cultivated areas. Many have been introduced intentionally and others have become dispersed as a result of cultivation, and are found especially in the immediate vicinity of railway stations. To this group may be assigned *Poa annua*, *Phalaris minor*, *Cynodon dactylon* (a dangerous invader), *Echinochloa colona*, *Digitaria sanguinalis*, *Bromus* and *Lolium* species, various species of *Eragrostis* and *Paspalum*, etc.

In summarizing, it may be said that the herbaceous plants of the basin of the river Uruguay consist predominantly—in the virgin grasslands—of tillering or root-propagated grasses, while in the basin of the river Paraná, especially in the areas under cultivation, seeding grasses predominate. In this connexion it has been observed that when a period of intense drought or prolonged invasion of locusts occurs and the grasslands are consequently bared of all leaf, after the first rainfall the Uruguay areas become green again in a few days, for this is the zone of the root-propagated grasses, while in the basin of the Paraná some fifteen days are required for the grasslands to become green, because here time is required for the germinative processes of the annuals which dominate the swards.

WATER GRASSES

(d) The water grasses. The grasses of the islands and marshes, sometimes called water grasses, are not so well known from the nutritive viewpoint. Pre-eminent species are *Panicum grumosum* and *Paspalum repens*, while *Ephedra tweediana* is found especially in the Paraná region. Other species mentioned are *Eragrostis hypnoides*, *Panicum laxum*, *Hymenachne amplexicaulis*, *Paspalum distichum* and *Eriochloa montevidensis*, all of which have been analysed for their chemical composition by the Faculty of Agronomy and Veterinary Science at Buenos Aires (Reichert, Trelles and Parodi, 1923, quoted by Baez, 1944).

It will be noted that many of these species are also found in the humid pampa, and Parodi has observed this in his survey of 1930, but states that in the Chaco, Mesopotamia (the two states of Entre Ríos and Corrientes) and Uruguay they are associated in a different manner.

POSSIBILITY OF IMPROVEMENT

Baez asserts that no actual forage problem exists in Entre Ríos, thanks to the climate, the fertile soils, and the plant cover; but serious problems of management do exist, the lack being one of foresight rather than of production.

An account of three Entre Ríos ranches is given by Davies (1940), who records a 60 per cent participation of *Paspalum notatum* and *Axonopus compressus* in typical old pasture (probably never ploughed) near Concordia in the Uruguay basin, approximately lat. 31° S. The summer grazing capacity of such pasture is estimated at about one cattle beast to two acres, and winter grazing at about one beast to four acres without supplementary food. He considers that the locust

is likely to be a deterrent factor in the intensification of pastoral agriculture in the region, but Baez (1944) does not attach so much importance to locust invasion, which he says is of a transitory nature only and for which compensation could be made by reserving areas of the more resistant virgin grasslands and by the conservation of fodder in the form of silage or hay, a practice at present almost unknown in the province. Davies records a deterioration in land which has been sown to oats and sorghums for grazing and then allowed to revert to grass, which it does in less than two years. "Such grassland does not seem to improve much with age, and has for many years a lower carrying capacity than before ploughing up." He envisages, however, great possibilities for the improvement of Entre Ríos pastures with a view to the production of more and better quality livestock. "One point of interest noted was that adjacent to the gateways and for a distance of some fifty yards around them the sward dominant was *Paspalum dilatatum*, the species that has established itself so widely in coastal New South Wales and Southern Queensland. *Paspalum dilatatum* is a more valuable pasture grass than the common *Paspalum* (*P. notatum*) of the Entre Ríos pastures. Its presence as the dominant in the heavily trodden and fairly heavily dunged areas around gateways would indicate that given proper management, and perhaps purposeful manuring, pastures of *Paspalum dilatatum* could easily be maintained on these fields." (Davies, 1940.)

SURVEY

Quite recently, through the kindness of A. T. Semple, analyses of thirty-seven typical Entre Ríos pastures have become available, and they are presented in Table 4. (Semple, 1946.)

The principal species of grasses found in 70 typical pastures of the Argentine provinces of Entre Ríos and Corrientes in April, 1943

Areas	Pastures examined	Plant	Pastures where found	Percentage of cover	Range in percentage of cover
North-western Entre Ríos	17	<i>Eleusine tristachya</i> Bur clover ... <i>Stipa hyalina</i> ... <i>Paspalum dilatatum</i> <i>Selaria</i> species ... <i>Stipa papposa</i> ... <i>Chloris ciliata</i> ... <i>Bouteloua megapotamica</i> <i>Sporobolus poiretii</i> ... Weeds ...	11 6 12 8 9 6 7 8 6 15	4 15 11 8 3 9 11 10 3 27	1-20 1-65 1-30 1-20 1-10 1-10 1-25 1-40 1-30 1-5 5-65
North-eastern Entre Ríos	8	<i>Chloris ciliata</i> ... <i>Paspalum notatum</i> <i>Tripogon spicatus</i> <i>Paspalum</i> species ... <i>Andropogon laguroides</i> <i>Sporobolus poiretii</i> ... <i>Aristida pallens</i> ... Weeds ...	7 5 5 4 8 5 5 8	29 22 14 9 7 4 4 23	5-50 5-60 5-40 1-25 1-15 1-10 1-10 10-40
South-eastern Entre Ríos	12	<i>Lolium multiflorum</i> Bur clover ... <i>Andropogon laguroides</i> <i>Eleusine tristachya</i> <i>Paspalum dilatatum</i> <i>Eragrostis lugens</i> <i>Stipa hyalina</i> ... Weeds ...	5 9 8 7 5 6 6 12	36 22 7 5 12 9 9 20	5-50 1-80 1-15 1-10 1-40 1-15 1-20 5-40
North-eastern Corrientes	14	<i>Andropogon lateralis</i> <i>Axonopus</i> species ... <i>Paspalum notatum</i> <i>Sorghastrum agrostoides</i> <i>Andropogon selloanus</i> <i>Paspalum plicatulum</i> <i>Eragrostis bahiensis</i> <i>Panicum milioides</i> Weeds ...	10 3 2 5 5 6 8 6	35 28 30 31 11 12 6 4 16	10-80 15-35 15-45 5-50 1-20 1-40 1-15 1-15 1-30
South Corrientes	19	<i>Tripogon spicatus</i> <i>Paspalum notatum</i> <i>Aristida pallens</i> <i>Chloris ciliata</i> ... <i>Andropogon laguroides</i> Weeds ...	10 13 11 14 13 17	26 20 12 7 6 16	1-50 1-60 5-20 1-30 1-15 10-20
TOTAL	70				

TYPE 1. GOOD NATURAL GRASSLANDS

(e) The Magellan Lands

Another borderline example is found in Magallanes, southern Chile, in a cooler climate. The economy of this province, lying between the parallels 49 and 56 and the meridians 76 and 78, is based practically entirely on the sheep-raising industry that has been built up within the last seventy years. In 1855 there were 34 sheep in the province; in 1928 the number was 2.5 million, and this figure has been maintained with little fluctuation up to the present day. Farming is of the wide, ranch type, the largest ranches being found in the island of Tierra del Fuego and in the Patagonian region or on the shores of the Straits of Magellan. In spite of a rigorous climate the flocks (mostly Corriedales and Romney Marsh) are healthy. (Agez, 1943 and 1944.)

FLORISTIC COMPOSITION

A description of the Magellan lands located in both Chile and Argentina has been given by Davies (1940). They comprise open grassland composed largely of valley flats or "vegas" separating ridges of forest or scrub. The rainfall is about 12 to 25 in. (304.8 to 635 mm.), the growing season is relatively short (October to April), the whole area is windswept, and during the winter low temperatures with snow are experienced. "The flats are probably old lake bottoms. . . . One outstanding characteristic of the vega's flora is the complete lack of clover and other legumes. The sward is usually grassy, or grasslike, and forms a tight mat without any bare soil showing in plan. . . . The flora is restricted to a few dominant species and the miscellaneous herbs are not abundant."

Hauman (1925) gives the following description of Patagonian vegas observed by him. "The natural flora of these little oases is not very varied; the grasses are naturally dominant and develop fairly luxuriantly there. *Hordeum secalinum* var. *pubiflorum*, 35 to 50 cm. in height, with silky ears now green, now tinged with violet, plays a preponderant role; then comes an *Agrostis* with purple panicles (*A. magellanica*), *Festuca* spp., *Deschampsia flexuosa*, *Atropis magellanica*, *Alopecurus antarcticus*, *Phleum alpinum*, *Calamagrostis*, with which are often mingled *Poa pratensis*, *Dactylis glomerata* and a European species of *Bromus* introduced in the seed of cultivated plants. The grass sometimes reaches a height of one metre. There are found also some species of *Carex*, *Heleocharis*, *Scirpus*, *Juncus*, *Triglochin palustre*, and all that composes a sward of an intense green made gay by the pink flowers of *Samolus spathulatus*, the violet flowers of *Gentiana magellanica* and *G. patagonica*, those of *Euphrasia antarctica*, white with red markings, and the umbels of *Apium australe*."

The vegas or valley flats, which have deep, fertile soil, appear to be all-important for the quality of these grasslands. The carrying capacity of the vegas is estimated at well over one sheep per acre, although the total carrying capacity of the region's sheep stations is given as one sheep per 1.5 to 3 acres. (Davies, 1940.) In this connexion Castellanos' definition of the term "vega" is of interest. It is said generally to denote cultivated fluvial valleys, but in the Andean paramos or highlands of Argentina it is used to describe wet meadow lands having a close plant cover of short therophytes and helophytes, green even in winter and forming an oasis-like contrast to the rest of the landscape. The formation is always found at the edge of watercourses or where there is surface water. (Castellanos, 1938.) Castellanos, like Davies, notes the affinity of this formation with the so-called "mallin" meadow formation.

Parodi writes that the "vegas" and "mallines" of Patagonia contain true meadowlands composed of Juncaceae, Cyperaceae and Gramineae of species of *Agrostis*, *Polypogon*, *Hordeum*, *Poa*, *Festuca*, *Deschampsia*, *Alopecurus* (*A. antarcticus*), *Agropyron*, *Elymus*, etc. (Parodi, 1945c.)

It is believed that the lands of the Magellan Straits region could be improved to something approaching first-class grasslands by first the introduction of clovers, and secondly the use of phosphates and the introduction of new grasses and herbs as well as the increased development of the better indigenous grasses and non-gramineous plants. (Davies, 1940 and 1946.)

TYPE 1. GOOD NATURAL GRASSLANDS

(f) The Pre-Andean Depression

It is just possible that the narrow belt of discontinuous lowland basins which run northwards from Punta Arenas on the Magellan Straits and form what is termed by James the Pre-Andean Depression (James, 1941, p. 318), might be included as borderline Type 1 grasslands. The basins, which have an altitude of between one and two thousand feet or approximately 305 to 609 metres, separate the steep eastern slopes of the Andes from the westernmost cliffed sides of the Patagonian plateaux and afford a continuous passage northward from the Magellan Straits as far as Lake Argentino (50-52° S.), and then extend farther north, although interrupted at intervals by spurs of the Andes, to approximately 38-40° S., the northernmost basin lying north of Lake Nahuel Huapi. The plant cover of these basins consists largely of short grass steppe.

Hauman (1925), in describing this region, which he terms the "Precordillera", notes that its rainfall régime constitutes a transition, very brusque and rapid, between that of the Patagonian plain (under 200 mm.) and that of southern Chile, where—less than 100 kilometres further west—the rainfall is certainly ten times greater. The region contains the series of Patagonian lakes, approximately twenty, and is traversed also by a network of small watercourses coming from the neighbouring mountains and flowing east. Moisture conditions, thus, are very different from those of the Patagonian desert. "Nevertheless", writes Hauman, "the modifications in the vegetation are not very marked. The flora is always that of the plateau, but on the one hand it is enriched by numerous elements peculiar to this frontier zone, and on the other its aspect changes rapidly by reason of the greater number of individuals, especially in the grasses." He appends here a footnote to the effect that stock raising is consequently more successful and, for the quality of its meat, a sheep from the Precordillera is popularly considered to be worth two from the plateau. "When one leaves the perfectly horizontal plain to enter one of the first little valleys of the Precordillera, the vegetation at the outset changes very little, but it is less stunted, many species already dried up further to the east are here still in flower, grasses of the species *Poa*, *Stipa*, *Festuca*, *Elymus* (*E. erianthus*) and *Bromus macranthos* are abundant." (Hauman, 1925.)

The southern part of the Depression has been successfully used for sheep ranching since 1855, and north of Lake Nahuel Huapi cattle ranching is of importance. (James, 1941.) Davies' description of herbage seen west of San Carlos de Bariloche on the shores of Lake Nahuel Huapi may be taken as a sample of what is possible in these grasslands. "To the west of the town rain forest predominates, while immediately to the east sub-arid grass steppe occurs. The change from one vegetation type to the other is very rapid and probably conforms closely to the incidence of rainfall." (Incidentally, it is noted that the surroundings are not unlike those found in the vicinity of the alpine lakes of the southern Alps, New Zealand.) "The chief interest lies in the herbage of fields and small clearings. Wild white clover abounds everywhere in these clearings, and the

pastures carry a typically British flora. The following statement will illustrate this point ; it shows the botanical composition of a small pasture field and a roadside verge.

Percentage area cover (Bariloche-Llao road)

30th March 1938

						Pasture	Road verge
<i>Trifolium repens</i> ...	...	...	...	...	...	8	20
<i>Holcus lanatus</i> ...	...	...	...	...	...	3	5
<i>Bromus mollis</i> ...	...	...	...	...	...	2	—
<i>Poa annua</i> ...	...	...	...	...	...	—	8
<i>Bromus catharticus</i> ...	...	...	...	...	...	—	5
<i>Poa pratensis</i> ...	...	...	...	...	...	5	—
<i>Plantago lanceolata</i> ...	...	...	...	...	...	15	5
<i>P. media</i> and <i>P. maior</i> ...	...	...	...	...	...	1	5
<i>Hypochoeris radicata</i> ...	...	...	...	...	...	22	18
<i>Rumex acetosella</i> ...	...	...	...	...	...	8	5
<i>Taraxacum officinale</i> ...	...	...	...	...	...	10	17
<i>Geranium molle</i> ...	...	...	...	...	...	3	2
<i>Veronica officinalis</i> ...	...	...	...	...	...	Trace	—
<i>Acaena</i> sp. ...	...	...	...	...	...	20	5
Other plants ...	...	...	...	...	...	3	5
						100	100
Bare space ...	...	...	...	...	...	20	5 "

Parodi (1937*d*) notes that the region of Lake Nahuel Huapi is rich in adventive grasses of European origin. This is probably due to intensified activity, tourist traffic, road-building and the opening up of communications with southern Chile. The species listed are *Holcus mollis*, *Arrhenatherum elatius*, *Schismus barbatus*, *S. arabicus*, *Bromus secalinus*, *B. rigidus*, *B. mollis*, and *Lolium subulatum*.

While the herbage of rain forest clearing and roadside verge is probably not typical of the Pre-Andean Depression steppe grasslands, they are likely to afford good grazing in so far as they consist of the admittedly valuable vega formation. Their value is noted by Torroba in a survey of Argentine forage resources. (Torroba, 1945.) Actual sward surveys are not available at present. At least as far north as Lake Argentina the Depression would partake of the moister conditions that characterize the Patagonian region south of the river Santa Cruz, conditions due to a break in the Andean chain which permits the passage of moisture-laden clouds. (Fiorda, 1940.)

CHAPTER 3

THE NATURAL GRASSLANDS

NATURAL GRAZINGS IN THE PROVINCE OF CORRIENTES, ARGENTINA, AND STOCK RAISING IN THE ARGENTINE CHACO

By L. R. PARODI

The Argentine regions described are transitional between Type 1, good natural grasslands, and Type 3, semi-arid grasslands, because while in general they lack the aridity of the latter, they have not the more temperate climate and good soils of the first type, and insect and parasitic pests are very real deterrents to the raising of first-class stock.

Natural pastures of the Province of Corrientes

The Province of Corrientes is a large plain crossed by numerous rivers and streams, tributaries of the rivers Paraná and Uruguay, and interspersed with lakes and marshes, some very large, as, for example, Lake Ibera, which occupies an area of 7,000 to 8,000 sq. km. The vegetation is very varied, but predominantly grassy. A line passing approximately through the longitude 57° 30' would divide the province into two parts, an eastern part characterized by the predominance of steppes and savannahs, with trees only on the banks of the rivers, forming fringe forest, and the other a western part covered with sparse woodlands of *Prosopis nandubey* and a species of *Acacia*, with a carpet of fine grasses suitable for sheep farming.

STOCK RAISING

Stock raising is of the extensive type, and there exist approximately 3,800,000 head of horned cattle, over 2,000,000 sheep, and more than half a million horses. In the proportion of horned cattle Corrientes occupies the fourth place among the Argentine provinces, and it is interesting to note that the animals are fed almost exclusively on the natural grazings. There are some factors which have an adverse effect on extensive stock raising; among these should be mentioned the diseases caused by *Tripanosoma Elmassiani* ("mal de cadera") and by *Piroplasma* sp. ("tristeza"), and the predominance of parasites such as the tick (*Boophilus*), the vector of Texas fever; insects such as those which transmit *Tripanosoma*; and the various insects that are very abundant at certain times of the year and do much injury by keeping the animals constantly in motion, thus retarding their fattening. Progress has been made in the control of the tick through a wider use of dipping.

Another important problem is that of water for the herds. As a rule natural springs, rivers, streams or lakes are available; in some lands with a sufficient difference of level it is possible to construct dams in which rainfall is accumulated; in the better equipped establishments it is common to use windmills with tanks and drinking places conveniently distributed over the grazings. The water is good throughout the Province. It is frequently necessary to supply salt to stock because the soils are generally poor in sodium chloride, and the use of salt licks is consequently common.

The growing of forage crops is very rare as yet, and such crops usually consist of different species of *Sorghum*, *Chloris gayana*, *Pennisetum*, etc. Lucerne, which is the fundamental forage crop of the Provinces of Buenos Aires, Santa Fé and Córdoba, develops badly in Corrientes because the soil is unsuitable for its cultivation.

In the more progressive establishments forage crops are grown for stalled animals; oats (*Avena byzantina*) and sorghums (*Sorghum caffrorum* and *S. sudanense*) are cultivated for this purpose. The former are fed dry, the straw and grains mixed, while the sorghums are cut and exposed to the air before being fed, in order to avoid possible accidents on account of their content of dhurrin.

PASTURES. EAST

In the eastern part of the Province there extend vast horizontal lands covered for the most part with *Andropogon lateralis*, a tall grass which gives the vegetation the aspect of a savannah; between its tufts there is a carpet of succulent grasses such as *Paspalum notatum* and *Axonopus compressus*, two of the most valuable grasses of this region, *Paspalum almum*, *P. plicatulum*, *Axonopus argentinus*, *Eragrostis lugens*, *E. flaccida*, *Sporobolus poiretii*, *Panicum sabulorum*, intermingled with legumes of the genera *Stylosanthes* and *Desmodium* and different species of the Rubiaceae, Oxalidaceae, Cyperaceae and Compositae, which together comprise herbage of excellent nutritive value.

NORTH-EAST

Further to the north-east, near Misiones, the lands are widely undulating, with fringe woodlands in the depressions and hard grasses on the slopes; among these there predominate rough grasses, having dry leaves in summer, of the genera *Aristida*, *Elyonurus*, *Andropogon*, *Panicum*, associated with tender herbage of the genera *Paspalum*, *Axonopus*, *Eragrostis*, *Stylosanthes*, *Desmodium*, etc. Such tall grasses are little suited for the raising of sheep, for which reason they are used for cattle, especially the native race which is the most resistant in this tick-infested region, exposed to the intensely hot sun. These lands are commonly burnt to encourage the appearance of fresh shoots after the rains and to destroy the ticks which are harboured in the grass tufts.

CENTRE AND SOUTH

In the central and southern parts of the province the vegetation consists of sparse woodlands with a grassy sward suitable for the raising of sheep and cattle. In the middle of summer these lands are generally quite green, the Paniceae and Andropogoneae predominant. The best forage plants here are *Paspalum notatum* and *Axonopus compressus*, which form a close carpet in association with *A. argentinus*, *Rottboellia selleana*, *Paspalum plicatulum*, *P. almum*, *Digitaria fallens*, *Andropogon lagroides*, various species of *Desmodium*, all excellent and very resistant to trampling. With them are found "strong" * grasses such as *Stipa neesiana*, *S. papposa*, *Briza subaristata*, *Sporobolus aeneus*, *Panicum bergii*, *Aristida venustula*, *A. uruguayensis*, *Andropogon salzmanni*, etc. In the higher lands a transition from steppe to savannah is seen in the predominance of *Andropogon lateralis* and the presence of *Aristida circinalis*, *A. pallens*, *Chloris canterai*, *Tridens brasiliensis*, various species of *Mimosa*, *Calliandra*, *Verbena*, etc. In some fertile lands a poisonous plant, *Baccharis coridifolia*, makes its appearance, frequently in great abundance, but it is easy to eradicate by ploughing the land.

The lower meadows, with humid soil, are covered for nearly the whole year with herbage composed of a mixture of species whose growth is successive throughout the four seasons; there predominate *Paspalum notatum*, *P. pumilum*, *P. almum*, *P. nicorae*, *P. cromyorrhizon*, *Axonopus compressus*, *A. fissifolius*, *Eriochloa montevidensis*, *Hemarthria altissima*, *Rottboellia selleana*, *Sporobolus poiretii*, *Panicum sabulorum*, *P. milioides*, *Eragrostis flaccida*, *E. interrupta*, *Setaria geniculata*, various species of Cyperaceae of the genera *Heleocharis*, *Fimbristylis*, *Carex*, different species of the Leguminosae, Solanaceae, Rubiaceae, Compositae, etc. Interspersed with and

* Definition of strong grasses, p. 19.

over-topping this herbaceous sward are the under-shrubs *Heimia salicifolia*, *Baccharis*, *Eupatorium*, *Vernonia* and bunches of other grasses such as *Paspalum quadrifarium*, *P. rufum*, *Andropogon lateralis*, etc. In the marshes certain herbage very palatable to cattle grows, such as *Luziola peruviana*, *Leersia hexandra*, *Diplachne uninervia*, *Panicum helobium*, *P. dichotomiflorum*, *Paspalum acuminatum*, *Echinochloa crus-gavonis*, etc.

It is probable that the good quality of the wool coming from this region is due to its cleanness, because there are lacking here the fruits of *Xanthium* and similar plant species which become attached to fleeces in other regions and detract from their value, and the fibre perhaps is more homogeneous because the sheep have herbage throughout the year.

NORTH-WEST

In the north-western zone sparse woodlands alternate with savannahs and marshes covered with tall grasses. The sward in the woods of *Prosopis nandubey* and *Acacia* is variable in accordance with locality, but commonly tender herbage of the genera *Paspalum*, *Panicum*, *Axonopus*, *Eragrostis*, *Rotboellia*, *Setaria*, *Eleusine*, *Desmodium*, *Oxalis*, etc., is abundant and suitable for raising sheep and cattle; in the savannahs, on the other hand, species of *Elyonurus*, *Aristida*, *Chloris*, *Setaria*, *Axonopus* and other hard grasses predominate, dry in summer and therefore readily burning. The marshes are generally covered with tall species of *Paspalum*, *Panicum*, *Erianthus*, *Cyperus*, *Canna*, *Thalia*, etc.

For analyses by Semple of thirty-three pastures in the north-east and south respectively of Corrientes, see Table 4. (Semple, 1946.)

Stock raising in the Argentine Chaco

STOCK RAISING

The parklands of the Chaco, as shown on the map (excluding the Pampean woodlands, see Fig. 6) is the most extensive phytogeographical region of Argentina; its area is estimated to be 655,000 sq. km. It is very difficult to ascertain the total quantity of cattle raised in this region, because, besides the Provinces of Santiago del Estero and the Governments of Formosa and Chaco, parts of other provinces are also embraced. Nevertheless, the small proportion of cattle that exists in the typical Chaco zone can be deduced by reckoning up the cattle of the territories just mentioned (Santiago del Estero, Formosa and Chaco). Each of these has approximately 600,000 head of cattle; Santiago del Estero has about 600,000 sheep, but as the herbage is scarce and mediocre a large area is devoted to the raising of goats, which in this Province reach a maximum figure of 900,000. Formosa and the Chaco have 30,000 and 50,000 sheep respectively. The same factors adverse to stock raising which were mentioned for Corrientes ("mal de cadera", "tristeza", etc.) are common to this region also, but are aggravated by the greater scarcity of water in the central zone.

The eastern zone (zone A on the map, Fig. 6) is the most favourable for stock raising on account of its humid climate, which is similar to that of Corrientes; there grows in general the same good herbage as in that province, and good water is available. The islands of the Paraná are important refuges to which it is customary to take herds from the interior grazings during the dry seasons. In addition, in the Santa Fé zone lucerne and other forage crops such as sorghum and oats can be cultivated, which allows an increased number of more highly bred animals to be kept.

EASTERN ZONE

In this zone there is an abundance of tender herbage such as *Hemarthria altissima*, *Paspalum dilatatum*, *P. alnum*, *P. notatum*, *P. urvillei*, *Axonopus compressus*, *Paspalidium paludivagum*,

Panicum pilcomayense, *P. milioides*, *Setaria fiebrigii*, *S. geniculata*, *Andropogon saccharoides*, *Eragrostis lugens*, *E. flaccida*, *Chloris canterai*, *Ch. polydactyla*, *Diplachne uninervia*, *Echinochloa crus-pavonis*, *E. helodes*, *Eriochloa montevidensis*, different species of *Desmodium*, etc., of excellent forage qualities.

CENTRAL ZONE

In the central zone (marked B, Fig. 6) ecological conditions are less favourable for stock raising: the climate is hot and dry, the herbage hard and mediocre, subtropical pests are abundant, water is scarce, and the distances to means of communication are great.

The soil is very horizontal and deep, in some places sandy. The rivers and streams traverse the surface of the ground so that they readily overflow during the rains, and water is accumulated in the lower parts so as to produce natural reservoirs. These consist of large lakes or so-called blind rivers, with no outlet, frequently several kilometres across, on the shores of which there grow numerous trees forming a marginal wood. These natural deposits of water are in many parts the only reservoirs for watering stock. Except in the southernmost region, artificial wells are rare in this territory.

The plant cover is formed of savannahs which alternate with patches of woodlands; the savannah consists of tall grasses, in general only of medium value as forage; in the higher lands species of *Aristida*, *Elyonurus*, *Chloris*, *Trichloris*, *Trichachne*, *Pappophorum*, *Setaria*, *Pennisetum*, *Cenchrus*, etc., predominate. Frequently an *Elyonurus* species represents 80 per cent of the vegetation, the grassland being then of only mediocre value for stock raising. In this zone a tree of medium height, sometimes with the appearance of a shrub, having a tendency to invade grassland, is common; it is *Prosopis ruscifolia*, which is dispersed through the cattle eating the fruits and the seeds becoming disseminated in the excrements.

Many lands in this zone could be improved by the introduction of suitable forage cultures such as, perhaps, certain species of *Sorghum*, *Pennisetum*, *Melinis*, *Desmodium*, etc. On some ranches where *Sorghum caffrorum* is cultivated it grows well, resists drought admirably and gives a good yield.

In the central part of Formosa there is no lack of large marshlands having the tender herbage preferred for the raising of cattle. The basis of the herbaceous cover is formed by *Echinochloa crus-pavonis*, *Paspalum intermedium*, *Hemarthria altissima*, *Setaria geniculata*, *Diplachne uninervia*, *Cyperus giganteus*, etc. As the marshes are not deep, animals can enter them and find green herbage throughout practically the whole year.

SOUTH-WESTERN ZONE

In this zone trees predominate over the herbaceous plant cover, giving rise to close woodland with few openings and exiguous grass growth. For this reason stock raising is not important, and goats are most suitable in this environment. In the small openings and in the undergrowth, which is formed of xerophyllous, small-leaved trees, the light enters and encourages the growth of grasses such as *Setaria fiebrigii*, *Panicum fasciculatum*, *Eragrostis*, some species of *Amaranthus*, *Portulaca*, etc., which, although in small proportion, are of some importance because they are added to the few which already grow in the openings, such as *Trichachne penicilligera*, *Pappophorum mucronulatum*, *Sporobolus pyramidalis*, *Eragrostis longipila*, *Setaria cordobensis*, *Bouteloua lophostachya*, *Chloris ciliata*, *Portulaca* sp., *Talinum*, *Zinnia uniflora*, etc. These grow in such a low proportion that commonly the cover hardly amounts to 20 per cent. Horned cattle exist in these woods by eating the few herbage plants named above, fallen leaves, the shoots of different trees such as *Schinopsis lorentzii*, *Acacia* sp., *Prosopis* sp., etc., and especially the fruits of *Prosopis*

and of *Acacia moniliformis*. In some places the great quantity of fruits that is eaten by animals can be determined from the excrement, which consists for more than 50 per cent of seeds of *Prosopis* and *Acacia*. In fenced-off land where no animals graze, for example, by the side of railways, the grasses and herbaceous plants just mentioned grow in greater proportion and more vigorously, which proves that if the grazings were less heavily stocked there would be sufficient herbage to fatten the animals. Along the river Dulce, in the irrigation zone of Santiago, lucerne is grown successfully, five or six cuts being obtained per year. This is used on the local ranches for the fattening of butcher's animals or for transporting in bales to other localities.

NORTH-WESTERN ZONE

In this zone conditions for stock raising are favourable on account of the higher rainfall and the predominance of better herbage. The savannah is composed of hard grasses mixed with tender herbage; species of *Paspalum* are abundant (*P. urvillei*, *P. commune*, *P. elongatum*, *P. notatum*, *P. plicatulum*), *Setaria*, *Panicum*, *Eragrostis*, *Andropogon*, *Chloris*, *Trichloris*, *Trichachne* (*T. insularis*, *T. penicilligera*), different species of the Leguminosae and Compositae, etc. In this zone the native and cross-bred races of cattle are generally kept. Nearer the mountains, in the region of the low valleys, at an altitude of approximately 1,000 metres, the soil is heterogeneous but the climate is fresher and the tender herbage more abundant; the plant cover is in general of an orchard country type*, with *Acacia* and Cactaceae and grasses similar for a large part to those of the sparse woodlands of the south of Corrientes. Lucerne is grown without difficulty where the soil is deep, or *Chloris gayana*, which has found here so favourable a habitat that it may frequently be observed growing wild. Under these conditions stock raising is much more prosperous.

* Tansley, A. G., and Chipp, T. F. Aims and methods in the study of vegetation, 1926, p. 210.

CHAPTER 4

THE NATURAL GRASSLANDS

TYPE 2. COOL MOUNTAIN GRASSLANDS

(a) The Andean grazings of central Chile

At the present time Chile is at grips with something like a crisis in her agricultural industry. Although the area of the country is vast and the predominant use of the land is pastoral, either directly as pasture or for forage crops such as lucerne, oats, clover and pulse plants, Chile is unable to supply the needs of her growing population in meat and dairy products and has to import considerable quantities from abroad.

PASTORAL INDUSTRY IN CHILE

While the real Chile is agricultural, a vigorous and growing manufacturing industry has come to the fore within approximately the last forty years. This industrial growth with its considerable use of hydroelectric power, and the development of big mining industries give Chile the foremost place among the Latin American countries in the use of machine energy. (James, 1941.) Industry is centred in four large cities, and the relatively recent formation of large urban communities may have some connexion with increased demands for meat. (Repercussions of these demands are reported from Argentina, where the meat packing and chilling factories—to meet the increased requirements of Chile and Bolivia—have been seeking animals for slaughter even from the regions normally devoted to reproduction and breeding rather than fattening, to the detriment of the reproduction level. *Noticioso, Buenos Aires, 1944b.*) It is probably the relative inaccessibility of Chile's southernmost provinces, Aysen and Magallanes, in the second of which a flourishing stock industry has arisen within the last sixty years, which has hitherto prevented more advantage being derived from the good grazings of this region, so that for the moment it is central Chile alone that comes under consideration.

POPULATION AND CATTLE

The population of Chile is concentrated in the central region, comprising approximately the area situated between Coquimbo (lat. 30° S.) and Chiloe in the south and excluding the northern arid lands and the southernmost region. The south is distinguished by high rainfall and is sparsely populated. In the central region the birth rate is very high. From 1908 to 1938 the population of Chile increased by 40 per cent, but at the same time the number of cattle actually declined, so that in this period the proportion of cattle per inhabitant fell from 0·7 to 0·55. (Opazo, 1939, and Elgueta, 1943.) Vergara (1938 and 1943) estimates the cattle population of central Chile as 12·5 per 100 hectares, as against 20 in the Argentine Republic, 36 in Switzerland, and 41·7 in Uruguay for the same unit area. It is considered that under Chilean conditions, however, it should be possible to carry 20 head of cattle per 100 hectares.

DAIRY INDUSTRY

The dairy industry of Chile is also far from developed. The average annual milk consumption per head is approximately one-tenth (46 litres) of that of countries in northern Europe (England 400, Sweden 418, and Denmark 635 litres), and butter consumption is still lower, namely, 600 grm. per person in comparison with 10 kg. in northern Europe. Nevertheless it is asserted that Chile disposes of optimal conditions for the development of the dairy industry, especially in the south, conditions which could, indeed, enable it to compete with other butter-exporting countries. (Matthei, 1939.)

Vergara, deploring a recent suggestion that the country's resources should be exploited primarily from the industrial viewpoint, urges that industry cannot exist without agriculture, and with suitable encouragement Chile should still be able to produce abundant food for her own people even when the population has reached 7.5 millions, which should occur within about twenty years. (Vergara, 1943.) The area available for stock raising (hill lands, valleys and plains) is estimated at 150,000 square kilometres, while only 50,000 square kilometres are considered suitable for arable land. (Encina, quoted by Vergara, 1938.) The Statistics Office of Chile gives the area of scrub and natural grassland in the central region as 12,211.6 thousand hectares. (Vergara, 1938.) Of the various causes preventing the development of stock raising in proportion to the increase of the population, poor feeding, due primarily to the insufficient organization of fodder production, must be indicated as the most important. (Vergara, 1938. Opazo, 1939. Elgueta, 1943.)

PRESENT TRENDS

Energetic measures are now being taken to improve the situation, wherein the Department of Genetics and Plant Industry of the Ministry of Agriculture is working in close collaboration with the Experiment Station of the National Society of Agriculture, a vigorous and progressive association of agriculturists which was founded in 1838 and for over a hundred years has done great service in the promotion of agriculture and agricultural research in Chile. Their efforts are supported by a semi-fiscal organization named the Development Corporation of Chile, which was established by law on April 28th, 1939, for the particular purpose of attaining a more diversified economic structure and reducing the dependence of Chile upon the mining industries. An important part of the Corporation's work is the development of the cattle industry. (*Foreign Commerce Weekly*, 1944.)

RESEARCH

A comprehensive programme of work has now been set in progress by the Ministry's Department of Agriculture and the National Society's Experiment Station. At present, emphasis is placed on the study of indigenous and exotic species of herbage plants. Of the latter over 250 have been brought to Chile for trial. These plants are now being tested in grass gardens located in different places over an area extending from Ovalle (30°33' S.) to Llanquihue (41°15' S.). Herein there are tested adaptability, nutritive value (by chemical analysis) and resistance to frost, drought and disease. In addition, note is made of the degree of aggressiveness, the abundance and size of the seeds and of any other indications that a given species might develop into an undesirable weed. In such a case the dangerous species is entirely eliminated from the trials, or else kept under extremely strict control. It has already been possible for the experiment stations to determine the value of certain plants and the zones for which they are suitable. In this connexion *Phalaris tuberosa* and species of *Bromus* and of *Trifolium* have been mentioned. Some of the promising species have already been reproduced on a large scale and distributed to farmers and estate owners, whose co-operation in the trials is sought. Over 150 hectares were devoted exclusively to grass seed production in 1943. (Elgueta, 1943.)

Clover will probably become of much importance for sown leys in Chile. Lucerne grazings of the Argentine pattern are said by Vergara to find impossibly cold winter conditions in the south of central Chile, the most extensive agricultural zone, but clover, which requires less warmth, thrives very well. It should be noted here, however, that lucerne is in fact being grown as far south as Punta Arenas (53°10' S.) in Chile and around Santa Cruz, Patagonia, both of which are colder than southern central Chile. (Davies, 1946.) Vergara reported the presence of large patches of clover spreading on hillsides in the province of Valdivia. It had been sown at some earlier epoch

and was growing wild, and the suggestion is made that Chile might well derive from clover as great a benefit as Argentina has derived from lucerne. (Vergara, 1938, 1. p. 201.)

Parallel with these trials, comparative trials are being made of various seeds mixtures for different conditions, experiments in manurial treatment are being conducted, and finally the natural grasslands of Chile are being surveyed by botanists who identify and classify the natural vegetation, determine the density of the cover, and take samples for chemical analysis. These explorations have already revealed the existence of valuable plants such as *Lotus uliginosus*, which are being subjected to more intensive trials. In the natural grazings the shrubs are of importance, and a special study is being made of these. It is hoped to determine the principles which make certain of these browse plants, such as *Cassia laevigata*, unexpectedly repulsive to animals. (Elgueta, 1943.)

This work is bound ultimately to have a far-reaching effect upon the Chilean stock industry. In the meantime herbage does not thrive in central Chile because of the lack of moisture, and a considerable degree of transhumance is therefore characteristic of stock management. (Matthei, 1939. James, 1941.) In these circumstances the mountain grasslands form a very important part of the herbage resources of the country. Matthei writes that "stock raising may be divided into two categories, the extensive type and the intensive. The former is practised generally in the great Andean ranches. The cattle are left to their own devices, for the mild climate allows grazing in the open throughout the year, and only from time to time are they rounded up in the narrow valleys and the folds of the hills. In the spring there is a great rodeo for the purpose of culling, classifying, marking the cattle, etc. In the better estates of the Longitudinal Valley stock raising is more of the European type; the animals are kept under cover in rainy and cold weather and supplementary rations of hay and concentrates are supplied at periods of scarcity. The great estates of the Central Valley generally have some land in the mountains: the hill lands carry the breeding cattle, the store cattle and dry cows, while the principal part of the estate, situated in the valley, carries the dairy cows, calves and animals for fattening." (Matthei, 1939.)

HILL GRAZINGS

The importance of the hill and mountain grazings is noted by Opazo. He describes several types, in the first place, the wintering pastures, which are grasslands described as "temporary" or those in which the natural herbage grows only for a given period of the year, generally the winter, spring, and part of the summer. The wintering pastures are situated in sheltered basins of the Andes; they have a considerable amount of shrub growth and browse plants and are relatively free of snow, and animals are sheltered from the weather by the closeness of the shrub cover. Because of these special conditions these grazings are reserved for winter feed, and the cattle eat the herbage which has grown in the summer and the new shoots of the shrubs and trees. Secondly he describes the summer pastures. These again are of the type called "temporary", occupying Andean valleys which are covered with snow during the winter. They are of little importance in the northern region because the Andes there are much dissected and the valleys are very narrow, so that the summer pastures which stock owners of the Province of Coquimbo use are situated mostly in Argentine territory; but south of the river Maule the summer pastures acquire greater importance, especially those situated between the Provinces of Bío-Bío and Chiloé. The value of these is considerable on account of the vast area which the Andean valleys occupy in this sector. The temperature allows the herbage to grow as soon as the snow fallen in the winter has disappeared. Once the herbage has sufficiently developed, it is used at once, namely, in the north from September onwards, in the central provinces from October and November, and it is grazed until March or April or until the time at which snow begins to fall and

the herbage has disappeared. These summer grazings are covered with very abundant and nutritive herbage which, as the name indicates, remains available for the whole summer, and they are suitable for all classes of stock and especially for breeding animals, which utilize their herbage very well. The dominant plants are *Festuca acanthophylla* and a smaller species of *Festuca* closely resembling it, *Poa* spp., etc.

PERMANENT GRASSLANDS

The grasslands described by Opazo as "permanent", which can be grazed the whole year round, are situated in somewhat lower lands having a temperate climate with a considerable amount of mist and atmospheric humidity, good rainfall throughout the year, and mild winters. In Chile this region is found south of the river Toltén and extends throughout the Province of Chiloé and as far as Magallanes, where it occupies all the valleys in which there is little snowfall.

HERBAGE

Of the plants described as characteristic of the summer grazings, the following account is given by Opazo of a species of *Festuca* (not further identified) named "coironcillo" and found in all the northern and central provinces of Chile from the coast to the Andes, where it occupies all the dry highlands. It is of very great value as a herbage plant because it is green for nearly the whole year and is grazed by every kind of stock. It forms tufts 20 to 40 cm. in diameter in accordance with the soil and the amount of moisture available, and it tolerates the intense heat and summer drought of the inland valleys. Its fine, coriaceous shoots remain green in the winter, spring and a large part of the summer, not drying and hardening until the end of this season, but it shoots afresh with the first rains of autumn, and sometimes much earlier merely with the atmospheric moisture that has been absorbed by the ground. *F. acanthophylla* closely resembles this grass but is larger, forming tufts 40 cm. in diameter and attaining a height of 50 to 80 cm. It affords valuable grazing for all classes of stock and is very abundant in the Andean grazings, although less abundant than the "coironcillo" and somewhat less drought-resistant. In the mountains of southern Chile its place is taken by *Poa fuegiana*, which resembles it and is known by the same vernacular name ("coirón").

Other herbage plants mentioned as growing in the highlands of Chile are *Poa* (over thirty species are found in Chile), recorded for dry uplands; *Chusquea* species, which furnish a coarse but useful fodder in winter, when snowfall promotes fresh shooting; *Stipa frigida*; *Sisyrinchium cuspidatum* (Iridaceae), grazed by all types of stock; *Brassica campestris* and *Rumex pulcher*, Andean region of Coquimbo. (Opazo, 1939.)

TRANSHUMANCE

In the central Andean region of South America transhumance is seen not only in seasonal migration from lowlands to mountain grazings and from mountain grazings to lowlands, but also from one country to another. Vergara has noted (1938, Vol. 2, p. 147) that numerous roads connect Chile and Argentina, facilitating the movements of cattle on the hoof, and that during periods of drought—which occur frequently on the eastern side of the Andes—it has been common for large numbers of Argentine cattle to be sent to graze in the valleys of central and southern Chile. On the other hand, as has already been noted, the principal summer pastures used by Chilean stock owners of the Province of Coquimbo, where the Andes are much dissected and the valleys narrow, are situated in Argentine territory. (Opazo, 1939, Vol. 3, p. 15.)

TYPE 2. COOL MOUNTAIN GRASSLANDS

(b) The Andean grazings of Peru and Ecuador

(i) Peru

CLIMATIC AND AGRICULTURAL ZONES

An enormously wide range of altitude, from sea level to 6,763 metres above it, is characteristic of Peru as of the other Andean countries, and with this range of altitude a great diversity of climates and of vegetation. Although "it is definitely incorrect to describe the Peruvian Andes

as composed of three or four parallel cordilleras, like the Andes of Colombia", for "the several ranges are not continuous and are generally arranged in echelon with no connexion between the separate rows of peaks" (James, 1941), yet a schematized view of the country's topography such as that presented by Knuchel (Fig. 13) is helpful in visualizing the various climatic and agricultural zones. (Knuchel, 1943.) Rainfall is abundant on the northern and eastern slopes of the Andes, and here the forests are found; the western slopes are very dry. A distinctive feature of highland Peru is a high-level surface of gentle slopes, above which stand towering groups and ranges of high

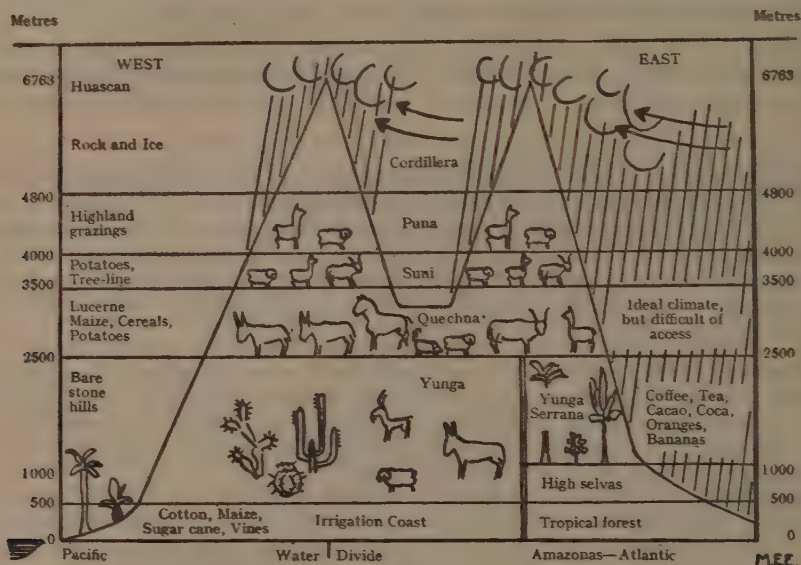


FIG. 13. PERU, CLIMATIC REGIONS AND AGRICULTURE

From Knuchel, Hermann

Schweiz. Z. Forstwesen

Vol. 94 No. 12. p. 352. 1943.

peaks, while below there are profound canyons with very steep sides. This high-level surface is very extensive. (James, 1941.)

The optimal zone for livestock is that extending from an elevation of 2,500 to 3,500 metres. In this region the climate is said to be ideal, and lucerne is grown in addition to cereals and other crop plants. A certain amount of stock is kept at lower (500 metres and upwards) and higher levels also, although the highland grazings (4,000 to 4,800 m.) can be used only for sheep and the native llamas and vicuñas. (Knuchel, 1943.) Within the highland region there are vertical zones based on temperature differences, and these zones again are diversified by variations of the rainfall factor. For example, snow lines are generally higher in dry regions whereas tree lines are lower, so that the zone of high grasslands is widest in dry areas and narrowest in wet areas. (James, 1941.)

The climatic conditions of the highlands of Peru are as diverse as the very varied surface features, and the upper limits of the different climatic zones (hot, temperate, cold) rise with increasing distance from the Equator to a maximum at about 20° S. In southern Peru, too, the annual range of temperature is somewhat greater than it is nearer the Equator; Cuzco has a range of about seven degrees as compared with three-tenths of a degree at Quito in Ecuador. Still

greater than the annual range of temperature is the range between day and night, and during the day there is a great difference between temperatures in the shade and in the sun respectively. (James, 1941.)

James' maps of land use show that very large areas and, in southern Peru, almost the whole of the highlands are used for livestock ranching without agriculture. In the uppermost regions the wool-bearing alpaca is a very important source of revenue to the large landowners and of subsistence for the Indian tenant shepherds. (James, 1941.)

PHYTOGEOGRAPHY AND FLORA

There is ample information on the phytogeography of Peru available in the works of Weberbauer (1911 and 1936), and a summarized account has recently been published by Williams (1941). A very valuable, detailed study of the grasses has been made by Hitchcock. In the introduction he notes that "in the uplands of Peru the native grasses produce abundant forage, which is increasingly utilized for sheep and cattle. Over large areas the dominant grass is ichu grass (*Stipa ichu*), a bunch grass with stiff involute leaves. This is grazed by stock only when the leaves are young. Sheep confine themselves mostly to the small species, such as *Muehlenbergia ligularis*, that grow between the bunches of ichu. The forage at high altitude is derived from a great number of native species belonging chiefly to *Festuca*, *Calamagrostis*, and *Poa*." (Hitchcock, 1927.) Important studies of the Peruvian flora have also been made by Macbride (1936) and Herrera (1930, 1941, etc.). Macbride's work contains a section on the Gramineae (102 genera) by P. C. Standley, and a continuation published by the Field Museum of Natural History, Chicago, in 1943, deals with the Leguminosae.

ANIMAL INDUSTRY

The cattle industry appears to be adequate for the covering of home requirements but not to envisage export except in the case of hides and skins. Wool, however, is an important article of export, and the Peruvian highlands afford much opportunity for the rearing of alpacas and sheep on a vast scale.

NATURAL GRASSLANDS OF PUNO

In this connexion an account of the natural grasslands of the Department of Puno, in the south of Peru, is of interest. It is written by R. V. Mendiivil, who contemplates the publication of a book on llama and sheep farming in the Department, and is issued by the Peruvian Ministry of Agriculture, 1941. The author is primarily concerned with measures to ensure the rancher against the consequences of drought such as that which devastated the Department's flocks in 1940, a year noted as unprecedented in this respect, although the dry seasons are always an obstacle to improved stock raising in Puno.

Three zones are distinguished in the Andean tableland, varying climatically in accordance with their altitude. The first zone is the lowest of the three, ranging in altitude from approximately 3,800 to 4,000 metres. The climate is mild, tempered by warm winds and rainfall; there is shelter, good and tall herbage, but little water.

The highest zone is that lying from 4,300 metres upwards to where the eternal snows begin. Its climate is severe and cold, there are cutting winds, snow and hail, the herbage is short and hard, the water supply abundant. Between these two zones comes the intermediate region situated between 4,000 and 4,300 metres in altitude; its characteristics are also intermediate between those of the other two zones.

The natural grasslands are mainly composed of grasses, rich in sugars and carbohydrates but poor in proteins. In the rich earths of the lowest zone, however, many legumes are found, and the improved quality of the herbage there is reflected in the stock, which is in better condition and more productive than that of the other zones. The animals kept are principally sheep and various types of llama (alpacas, vicuñas). Even the

better animals of the lowest zone, however, are described as "always small and frail, on account of the absence of mineral substances, especially calcium, in nearly all the grazings of the tableland."

Broadly speaking the best herbage—fine, close, varied and tall—is found in the richer alluvial soils of the lowest zone and especially in the more sheltered localities. The poorest grasses, short and ligneous, are found in the shallow soils of the highest zone, where the presence of great tufts of *Stipa ichu* is indicative of land of poor quality. In the flat and lower parts of the zone, where earth from the upper parts has accumulated, herbage grows satisfactorily. Herbage of approximately medium quality is found in the middle zone.

The quality of the plant cover is, again, largely affected by the configuration of the land and by its capacity for water retention.

The nutritive value of the herbage varies greatly not only from zone to zone, but from one locality to another and even from ranch to ranch. Still more does it vary in accordance with the seasons, being greatest when the herbage is in full fructification (April to May). As soon as the seed sets (June) the nutritive value begins to sink, the grass becomes mere straw and furnishes bulk only.

The dry season lasts for six or seven months and has an enormous effect on animal productivity and quality. For tiding stock and especially pedigree animals over this season, great importance is attached to the subdivision of grazings and to periods of rest. Manurial treatment is considered uneconomical except for liming, which is always valuable, especially in marsh localities. Irrigation by inundation is useful for establishing evergreen pastures on level surfaces for animals of the llama type, which suffer more seriously from drought than do sheep. Burning is held to do more harm than good. The fencing and reservation of pastures for three or four years is generally an adequate means of rejuvenation, but harrowing may also be done.

The following indigenous grasses are listed as being equal in value to introduced foreign grasses: *Bromus cartharticus*, *Festuca dissitiflora*, *Poa annua*, *Paspalum* species, and *Muehlenbergia fastigiata*. The seed of these grasses may be collected in May and June for re-sowing in November and December. Temporary leys are recommended for the richer, more sheltered lands of the lowest zone. For long-duration pastures foreign grass species are suggested, namely, *Lolium perenne*, *L. italicum*, *Dactylis glomerata*, *Alopecurus pratensis*, *Festuca pratensis*, *Festuca elatior*, *Sorghum sudanense*, *Cynodon dactylon*, etc. (seeding rate approximately 25 kg. per hectare), and as legumes *Medicago sativa* and the different clover species. Sowing and re-sowing should be done from November to December, and the fields should be kept well irrigated until the herbage gives a close cover and becomes perfectly acclimatized. A good tilth must precede, and harrowing follow sowing.

For temporary leys very good, tall and hardy varieties of barley, rye and oats are available. The barley and oats are excellent for hay and silage, but as they exhaust the soil to a considerable extent, care must be taken to grow them in fenced plots, well cultivated, well manured, and under permanent irrigation. (Mendivil, 1941.)

STOCK-BREEDING FARM

The Peruvian Government have established a stock-breeding farm at Chuquibambilla in the Department of Puno, the Granja Modelo de Puno, at an altitude of 13,000 feet (approximately 4,000 metres). It has 611,000 head of graded stock, fenced-in grasslands, a well-appointed home-stead, and an up-to-date woolshed and veterinary laboratory. Sheep are the main object of breeding, but some cattle and smaller animals are also bred. An account given of this model farm by Stordy (1938) shows that valuable work is being done which in the course of time should have an effect not only on the quality of the livestock raised in the Peruvian highlands, but also on the quality of the grazings.

Horses are unable to thrive in the plateaux of the Andes and cattle also have a precarious existence there unless born in the locality or introduced when extremely young. It has been found possible to introduce pure-bred stud rams and bulls when young, however, with entirely satisfactory results. Preliminary attempts to acclimatize new animals at somewhat lower elevations were unsuccessful. Whereas certain diseases tend to appear in horses and cattle because of the great elevations, sheep and the native llamas suffer no inconvenience, and there is an absence of animal plagues or epizootics, so that the health conditions of the Andean tablelands, writes Stordy, "afford a security to the stock farmer which few countries can offer".

HERBAGE

Stordy notes as the principal grasses a species of *Distichlis* (probably *D. humilis*), *Sporobolus fastigiatus* (*Muehlenbergia fastigiata*), and *Muehlenbergia peruviana*, and says that they afford excellent feed for all classes of stock. Although they dry up and lie dormant for six months of the year during the dry season, this is not regarded as any disadvantage, for in this condition the grasses constitute a form of "standing hay" and the rapid conditioning of the sheep which graze them gives ample evidence of their nutritive value even when dry. There is an almost entire absence of burrs, grass seeds, noxious weeds, etc., in these high tablelands. Two areas of permanent pasture have been laid down with seed imported from England and have given gratifying results. They are used for making hay and for supplying a change of dietary for sick or weakly animals. The carrying capacity of the farm's grazings, when fenced, is two sheep per hectare per annum.

MANAGEMENT

The Puno Model Farm attaches great importance to fencing, which is considered to offer security from trespass by vagrant rams or scab-infested flocks, and to benefit the swards by the congregation of flocks within a given area, while rotational grazing is made possible, the carrying capacity of the land is increased and its market value so enhanced that the initial cost of the fencing is regarded as a sound investment. (Stordy, 1938.) In the direction of management also establishments such as the Puno Model Farm are likely to benefit Peruvian stock raising to no small extent.

An interesting account of a 209-mile trip across the elevated plateau on which this experiment farm is situated is given by Renwick (1939). At the time of his visit "it was only the beginning of the rainy season, and the pastures were not so green as they would be a few weeks later. Many of the flocks were still far up on the cordilleras, just under the snow-line, where even in the driest weather the sheep can find feeding". He notes that the Puno region is one which has great possibilities for stock raising with the adoption of up-to-date methods, and says that the model farm has done valuable work in producing better breeds of animals and also in setting before the native shepherds new methods. Flocks of Merinos and Corriedales were seen in the vicinity of the farm.

LLAMAS AND ALPACAS

"From here onwards, we saw immense flocks of llamas and alpacas in the higher regions to which we had now ascended. In spite of the elevation, the pastures were excellent, and I saw many thousands of these interesting animals. It has been calculated that certain Indian communities have, sometimes, as many as 18,000 of them on the grazings which they have held from of old on a kind of co-operative, or joint ownership, basis." The vicuña, an animal of the same family as the llama and the alpaca but much smaller and more like a fawn, is found only in the wild state. Its wool is much finer and more valuable than that of the larger animals; the yield is small, however, and it has been sought rather for its skin than for the wool. Excessive hunting threatened at one time to exterminate it, but the Government of Peru has now made it a criminal offence to kill vicuña without special licence and the animals appear to be on the increase again. (Renwick, 1939.)

The Peruvian Government is now going further, and is establishing in the heart of the llama-rearing country (the Departments of Cuzco and Puno) a research station for the study and breeding of these profitable animals. Objectives include the determination of optimal grazing technique, which may well differ from that used in the case of domestic sheep, cattle, etc. Information is to be found in an account of the llama, the alpaca and the vicuña and their rearing in Peru, published by Gallegos (1944).

General descriptions of the indigenous "sheep" of western South America, the llama, the alpaca, the vicuña and the guanaco, have been given by Mascheroni (1941), Falbo and Elias (1943) and by Tappy (1944). They graze "in serene comfort" at altitudes of up to 5,000 metres, where other animals could not exist, and their grazing range really begins where that of the ordinary sheep ends. They are more numerous in Peru than elsewhere, but they also exist in the Lake Titicaca region of Bolivia, in the south of Ecuador and the north of Chile, and the guanaco (thought to be the original stock from which all these animals sprang) is found as far south as the Straits of Magellan. Efforts to transport them to other countries have been singularly unsuccessful.

RESEARCH IN PERU

The Puno Model Farm is one of a network of thirty agricultural experiment stations and substations working under the Ministry of Agriculture in all parts of the country, both coastal and mountain. At several of these the trial and acclimatization of introduced plant strains is in progress, but it is not known whether herbage plants are included among them. At only four of the thirty stations is actual plant breeding in progress, these are located mainly in coastal areas and no herbage or forage plants (with the exception of maize and the fodder cereals) are included in the material treated. A Peruvian geneticist has called attention recently to the need for much more work of this nature if the Peruvian farmer is to be supplied with good seed. He has drawn up a scheme whereby different plants, including herbage and forage plants, could be tested and bred for their suitability under all the very varied climatic conditions that characterize Peru. Under this plan twelve of the Ministry's thirty stations (in addition to the four already engaged in plant breeding) would carry out plant improvement in different parts of the country but under centralized organization, each to serve its own particular zone. Great importance is attached to the controlled reproduction of bred seed and its distribution to the farmer, all of which is provided for in the scheme. (Barducci, 1944.)

Since the foregoing was written, a Bulletin on the forage resources of Peru, written by Dr. Hugo W. Alberts, has been published by the Imperial Bureau of Pastures and Forage Crops. (Alberts, 1947.)

(ii) Ecuador

For an outline of the agricultural resources of Ecuador reference is made to a paper presented in 1940 to the Eighth American Scientific Congress by the Director General of Agriculture for that country, Sr. Don E. M. Ordeñana.

CLIMATIC AND AGRICULTURAL ZONES

The double range of the Andes, crossing Ecuador from north to south, has divided it into three natural, sufficiently well-defined zones, each having a different and characteristic fauna and flora and a different type of agriculture, each fulfilling its own especial functions. They comprise the littoral or coastal zone, extending from the Pacific to the foot of the Andes and rising to an altitude of approximately 800 metres; the interior or inter-Andean zone, composed of the valleys and table-lands of the two chains of mountains; and the eastern or Amazon zone, stretching eastwards from the foothills of the Andes.

It is the interior or inter-Andean region that is of interest for animal husbandry of all kinds. The temperature of the mountains is graded almost mathematically with altitude above sea level; a relatively hot temperature can be found in certain valleys up to 1,200 metres, but above this and up to 3,800 metres is the temperate, ideal cattle-raising zone, and above this altitude are the mountain grazings in which sheep and llamas are grazed. The region is in general rainy or moist. Rainfall, very variable in accordance with locality, is distributed throughout the months of the

year. Some places are as rainy or more rainy than localities in the coastal zone ; there are others that are excessively dry. Innumerable streams and waterfalls intersect the region, and crops are generally cultivated under irrigation.

The soil, of volcanic origin, presents a scale of mineral riches very varied in accordance with locality, although in many cases organic matter is rare. (Ordeñana, 1942a.)

Quevedo, writing of the province of Cotopaxi, notes that stock raising takes place mainly in the well-watered, temperate inter-Andean tableland and in the colder uplands. In the former region immense areas are devoted to cultivated herbage and forage plants, of which *Medicago sativa* is the most important. A lucerne culture here will last from eight to twelve years, giving five to seven cuts annually. Other plants cultivated are *Trifolium repens*, *T. pratense*, *T. amabile*, *Festuca ovina*, *Holcus lanatus*, *Phleum pratense*, *Anthoxanthum odoratum*, *Lolium* spp., *Onobrychis sativa*, and *Dactylis glomerata*. The natural highland grazings, on which hundreds of cattle, sheep, llamas and other animals feed, are composed mainly of species of *Deyeuxia* and *Festuca*, between the tufts of which are found a large number of mountain plants (listed) including *Lupinus tauri*. (Quevedo, 1942.)

Both Ordeñana and, in a brief review of the vegetation of Ecuador, Svenson mention the intensive nature of crop cultivation in the inter-Andean valleys, in large areas of which, according to Svenson, the native flora has practically ceased to exist. In addition to the páramos, which furnish grazing at certain seasons, there are high volcanic slopes above 4,000 feet (1,220 metres) which have much in common with the so-called puna zone of Peru and exhibit rapid changes from a blooming season to arid, almost desert conditions. (Svenson, 1941.)

HERBAGE

Hitchcock (1927) has studied the grasses of Ecuador, but unfortunately no study of the grasslands *qua* grasslands has yet appeared.

Ecuadorian grasses of the tribes Agrostideae and Aveneae were revised by Sodiro and the work was published after Sodiro's death by Mille (1929-30 and 1945). Of the grasses revised the most important genus economically is *Deyeuxia*, an essentially Andean plant whose species, together with those of *Festuca*, form immense swards that cover the upper part of the cordilleras. These swards not only provide good grazing for stock but are also a protection from erosion and a means of distributing rainfall evenly, so that it percolates into the soil and returns as springs. Some forms of *Agrostis*, *Polypogon*, *Holcus lanatus*, *Corynephorus canescens* and *Sporobolus tenacissimus* are cultivated in the mountains. (Sodiro and Mille, 1929-30 and 1945.)

Certain grass species are found at very great heights in Ecuador. Paredes, of the University of Ecuador, Quito, records the finding of a species of *Agrostis* at altitudes of up to 4,500 metres on the northern slopes of the volcano Tungurahua, and describes grass associations between 1,900 and 2,000 metres with *Eragrostis densissima* Hack. dominant and at 2,300 to 2,500 with *Aegopogon cenchroides*, an *Agrostis* and a *Paspalum* species conspicuous. At 3,450 metres *Lupinus pubescens* and *L. rupestris* are recorded among plants not seen below this zone. *Andropogon argenteus* was found between 3,700 and 3,720 metres. (Paredes, 1942.)

The Ministry of Agriculture for Ecuador has recently published a treatise by Katz (1943) on the indigenous herbage plants and such as are worthy of introduction, and on measures desirable for the improvement of grassland and its management in that country. In this work Katz notes that wool-bearing animals, sheep, llamas, and alpacas, are of very great importance for Ecuador because there are vast areas suitable for their feeding, and for this purpose he mentions the dry herbage of the páramos and the stony lands of the mountains with their cover of dry, fine, aromatic

plants. The country's present holding of one and a half million sheep might, he opines, be increased to eight million. A yield of 80 per cent could be relied upon, a fortune obtainable merely by the use of the natural grazings. (Katz, 1943.)

PRESENT POSITION OF ANIMAL HUSBANDRY IN ECUADOR

The zone between the two great cordilleras traversing Ecuador is described by James as composed of ten large basins arranged in a line from north to south. These basins lie between 7,000 and 10,000 feet (2,140 and 3,050 metres) and were originally covered with a dense growth of brush, but in the course of time much of the brush has been cut to make charcoal or burned to provide room for pasture, so that to-day grassy páramos cover about half the total area of the highlands. The intermont basins are used for subsistence agriculture and for grazing, and while most of the agricultural products of the region are used for local consumption, some cattle are sold regularly, though in small numbers, outside the region. They are driven down over the mountain trails and then it is necessary for them to be fattened on lowland pastures before they are marketed. (James, 1941.) There is no question of export, except in the case of hides and skins.

There is obviously room for the development of stock raising in the highlands of Ecuador. Katz has indicated the favourable conditions existing for wool production. At the same time he stresses the desirability of a diversified form of agriculture including well-managed and preferably fenced grasslands, quoting the saying: "Let him who wants bread sow herbage". (Katz, 1943.)

TYPE 2. COOL MOUNTAIN GRASSLANDS

(c) The mountain grasslands of Colombia and Venezuela

(i) Colombia

ANIMAL HUSBANDRY

In Colombia, although the stock-raising industry envisages the supply of the home market rather than export, it is of considerable importance in the national economy and cattle comprise a large part of the wealth of the country. (Wylie, 1942.) Of this very large country the plant cover is estimated to be composed of 50 to 60 per cent forest or woodland, but grazing lands also occupy a large area, 23 per cent or approximately 65 million acres. (Wylie, 1941.) The Chief of the Colombian Department of Animal Husbandry, Dr. M. Gómez Rueda, gives the area fit for use as grazings without any great modification as about 400 thousand square kilometres of the country's total of 1,139,155, and estimates that this would be sufficient to maintain 18 million head of horned cattle as well as other animals. The actual population of horned cattle in 1940, however, was only 9 million, and that of sheep 1 million. (Sheep are kept mainly in the upland plains, and their management is primitive.) Prospects for the development of the animal industry are nevertheless considered to be most favourable; growing interest has been evinced by private persons, and official support has become more effective. The demand for cattle both for home consumption and export increases daily, and prices are maintained at a good level. (Rueda and Reyes, 1941.)

CLIMATIC AND AGRICULTURAL ZONES

Although the whole of Colombia is situated in the tropics, it has many different climates governed by the topography. Three lofty Andean ranges, in addition to a much lower coastal range, intersect the country from north to south and are separated by large valleys descending to the torrid zone. In accordance with altitude several vertical zones are recognised, described by Dugand as follows: "The coastal lowlands up to an altitude of 350 metres and the immense plains of the Orinoco and Amazon basins as well as the low-lying valleys of the interior to about 500

metres above the sea are hot (mean temperature ranging from 27° to 30° C.) ; the highlands to an altitude of 1,000 metres are warm (mean temperature 23° to 26° C.). From this elevation to about 1,500 metres the climate is mild (mean temperature 20° to 22° C.), then more temperate to 2,000 metres (17°–19° C.), cool to 2,500 metres (14°–16° C.) and gradually colder above this level, reaching freezing point at some 4,500 to 4,800 metres, this being approximately the lower limit of the perpetual snow on the highest mountains.

“ It is estimated that 70·5 per cent of the Colombian territory lies between sea level and 1,000 metres ; 15·8 per cent between 1,000 and 2,000 m. ; 10·5 per cent between 2,000 and 3,000 m. ; 2·6 per cent between 3,000 and 4,000 m. and 0·6 per cent above 4,000 metres.” (Dugand, 1942.)

GRASSLANDS AND STOCK

Grazings are found in all these zones, in the vast, hot plains of the Atlantic coast and of the Orinoco and Amazon basins on the east, on mountain slopes where the growing of crops would bring about erosion, and in the fertile tablelands of the colder regions. (Rueda and Reyes, 1941.) Approximately three-fourths of the people of Colombia live in the highlands, and it is in the highlands also that the best cattle are found, namely improved dual-purpose cattle bred from imported stock and also a native breed called the black-eared white cattle. The last-named breed is highly resistant to ticks, and the white hair minimizes heat absorption from the sun. The cattle of these highland regions receive good care and are relatively free from diseases and pests. (Wylie, 1942.) In these regions, too, the natural grasslands are best. (Rueda and Reyes, 1941.)

The mountain province of Cundinamarca, in which the capital city, Bogotá, is situated, has an area of planted pastures of over 732,000 acres (296,000 hectares), and of natural pastures 831,000 acres (336,000 hectares). The carrying capacity of planted pastures is estimated as 1 acre (·405 ha.) to 1 animal (cattle), whereas that of the ordinary savannah is 4 to 7 acres (1·62 to 2·84 ha.) per head of cattle. Again, the weight of finished cattle, ready for market, is estimated as 1,025 lb. on the highland plateaux, but only 880 lb. in the hot regions. (Wylie, 1942.)

MINERAL DEFICIENCY

The soils are in many places deficient in phosphorus, calcium, potassium and iodine, yet grass growth is luxuriant and not a few indigenous and exotic legumes thrive. Efforts are being made to exploit existing deposits of calcium and phosphorus and to use the bones commonly wasted. The use of mineral licks is also resorted to. (Rueda and Reyes, 1941.) It is recognised, however, that improved pastures furnish the best solution of the mineral deficiency problem, and at the Government Experiment Station of La Picota, situated in the highland basin named the Savannah of Bogotá, trials of plants, both indigenous and introduced, are being made for this purpose. (The city of Bogotá lies 8,727 feet (2,670 m.) above sea level.) An interim report on these trials has recently been presented, and shows how considerably the highland pastures could be enriched. (Abadia, 1943.) The following information, arranged under the plants concerned, is taken from the report.

HERBAGE

Medicago sativa. Yields obtained at La Picota : a Peru variety gave 10 tons green weight per hectare per cut, a cut being obtainable every 70 days ; a Boyaco variety gave 11 tons, cuts being obtainable every 55 days. These fields are irrigated in the dry season. The carrying capacity per hectare at La Picota, calculated on an average annual yield of 60·5 tons green weight per hectare, is three good dairy cows.

Trifolium repens, *T. pratense*, *T. incarnatum*, *T. hybridum*. White clover is described as the best legume for grazings in the “ cold lands ” of Colombia : yield at La Picota, 18,500 kg. green weight per hectare per year. It grows wild in fertile spots such as the sleeping-places of cattle. Red clover, although little known in Colombia as yet, has a great future as a hay and pasture plant there and will furnish a good substitute for

lucerne in places where the latter does not grow well. Average annual yield at La Picota, 65,000 kg. green weight per hectare, three to four cuts being obtainable per year. Crimson clover, given cheap seed, should furnish a valuable green manure, but as pasture has the inconvenience of being an annual. It has a wide range of adaptation to soil and climate. Hybrid clover is also little known in Colombia but has two excellent qualities, namely, adaptation to ordinary soils poor in lime, and ability to grow in marshy lands. Average yield per hectare at La Picota, 69,125 kg., three to four cuts being obtainable.

Medicago hispida var. *denticulata*. In the Savannah of Bogotá this plant grows from April to November: it has been propagated naturally and is seldom sown. *Trifolium dubium* grows wild, no commercial seed is available. *Trifolium amabile* grows wild in pastures and by roadsides.

Vicia villosa is hardy and resistant to cold and drought, and can be cultivated from altitudes of 1,360 metres to the páramos at an altitude of 3,600 metres. In the Savannah of Bogotá its vegetative period is six months. Grown for seed production at La Picota, the yield per hectare was 824 kg.

Pennisetum clandestinum, or Kikuyu grass, introduced into Colombia in 1928, has been successfully grown at altitudes ranging from below 1,000 metres to over 3,000 metres, although it has been more successful in the intermediate climates. Of the herbage plants under trial at La Picota, this grass is one of the most promising in regard to adaptability, ready propagation, palatability and nutritive value. Average annual yield per hectare at the Station: 37,500 kg. green weight.

Dactylis glomerata, introduced from the Old World, grows in Colombia at altitudes ranging from 2,000 to 3,200 metres, and the range could probably be extended, but it is not well-known in the country and exact information is lacking. At various places in the central Andean Cordillera, in fertile volcanic soils, it has given excellent results. Average annual yield green weight per hectare at La Picota, 40,000 kg. The fact that some farmers have found it unsatisfactory is attributable to its having been left to ripen too much, in the vain hope of obtaining optimal yields both of herbage and of seed.

Agrostis alba has flowered abundantly at La Picota but has not produced fertile seed. Average annual yield of green weight per hectare, 22,500 kg. Cattle are observed to eat it as a last resort only, preferring other herbage.

Festuca pratensis grows to a height of 60 cm. at La Picota and has given an abundance of good quality seed. Average annual yield of green weight per hectare, 27,700 kg.

Anthoxanthum odoratum is not a very good grass and is recommended solely for poor soils where better plants do not thrive. Yield, 27,000 kg. green weight. Although the seed is dear in Colombia (it is said to emanate principally from Germany), the grass seeds readily in the Savannah of Bogotá, for which reason it has become widely propagated and tends increasingly to invade pastures and displace more valuable grasses.

Lolium perenne produces 24,500 kg. green weight per hectare per year at La Picota. *L. italicum* has yielded 180,000 kg., cut every 70 days and irrigated when necessary.

Arrhenatherum elatius flowers and produces at La Picota seed that is good, although of low germination capacity. It attains there a height of 1.12 metres and gives an average annual yield of 42,300 kg. green weight per hectare.

Chloris gayana. Yield at La Picota, 42,500 kg. green weight per hectare per year. The seed produced in Colombia is unfortunately dear and of poor germination capacity, a fact which prevents its wider diffusion. *Paspalum dilatatum* is a valuable and hardy grass which can be grown in every climate, from cold to hot, and in all types of soil, including marsh. *Holcus lanatus* gives a yield of 15,000 kg. at La Picota, but is a poor grass that should be replaced as far as possible by better herbage. *Bromus catharticus* is a grass of cold climates. *Pennisetum purpureum* gives 107,750 kg. green weight per hectare per year at La Picota.

Other plants under trial at La Picota are *Trifolium alexandrinum*, *Ornithopus sativus*, *Hedysarum coronarium* and *Melilotus alba*.

Indigenous plants of interest, concerning which little information is as yet available, are the following: *Spilanthes americana*, *Agrostis perennans*, *Sporobolus poiretii*, an *Alchemilla* species, and *Meibomia uncinata*. (Abadia, 1943.)

It is possible that the *Alchemilla* species to which reference is made is *A. pinnata*, already studied in Argentina and found to be of high nutritive value. (Ringuelet, 1941 and 1942.)

IMPROVEMENT

That a certain amount of success in the improvement of the highland pastures has already been achieved is recorded by Rueda and Reyes (1941), who write that at the outset the grasslands of the

high plateaux, like those of the lowlands, were very deficient in legumes, but now *Trifolium repens*, *Medicago hispida* var. *denticulata* and others have been widely distributed and are becoming incorporated in the natural and sown herbage in such a way as to provide in the cold zones the most well-balanced pastures of the country.

MANAGEMENT

The ranch or extensive system of stock raising is that generally employed in Colombia, cattle being allowed to roam over large areas of land. "It is a world . . . of huge *ranchos* and cattle by hundreds of thousands." (Wilson, 1942.) It is considered by the Department of Animal Husbandry, however, that a modification of this system is desirable in most parts of the country, and in the vicinity of the towns, where the land is highly valuable and dairying constitutes the principal form of animal industry, its continuation is economically unjustifiable. The heavy initial cost of planting soilage and hay crops such as *Zea mays*, *Tripsacum laxum*, *Lolium* spp., *Avena sativa*, *Medicago sativa*, and *Trifolium pratense* is, it is argued, more than balanced by the yields obtained. In addition, cut crops are well utilized, no energy is wasted in seeking food and the ration can be exactly balanced. If one hectare of pasture will keep a cow for a year, the same hectare sown with soilage crops will keep four or more. (Rueda and Reyes, 1941.)

(ii) Venezuela

CLIMATIC AND AGRICULTURAL ZONES

As in Colombia, a wide range of climates characterizes Venezuela, and three vertical zones are distinguished. The so-called hot lands in which the great plains of the Orinoco are situated extend from sea level to 1,000 metres; the mean temperature is 28° to 21° C. The temperate zone extends from 1,000 to 2,800 metres, and the mean temperature here is 20° to 12° C. The cold lands occupy the terrain from 2,800 metres up to 5,000 metres, the mean temperature being 11° to 0° C. or less. In general there are two sharply defined seasons, namely, the summer, November to April, which is dry, and the winter, May to October, which is wet, but in the coastal and Andean ranges the winter season is more or less irregular. In general, annual rainfall increases with altitude. With the exception of the Orinoco delta (where there is perpetual rainfall, torrential from April to August and more moderate but always copious from September to March) the average annual rainfall of Venezuela oscillates from 800 to 1,800 mm., with 75 to 150 days of rainfall. (Pittier, 1926 and 1939.)

The great Orinoco plains are bounded on the north by the coastal range or Central Highlands, on the west by the Sierra Nevada de Mérida, a part of the Andes and the only part of the Venezuelan highlands where permanent snow is found at the higher elevations, and on the south by a region known as the Guiana Highlands, which reach their highest altitude at 2,810 metres.

HILL AND MOUNTAIN GRASSLANDS

While no concise account of the distribution of the grasslands of Venezuela is yet available, there are indications that the grazings of the temperate and colder zones are of more value than those of the hot zone. James' map of land use in northern Venezuela shows that much of the mountain and hill land is used for "livestock ranching without agriculture" (James, 1941, p. 57). Pittier writes that "large areas of the forest of the temperate zone have had to be destroyed by fire in order to provide grazings for types of cattle which are in every way superior to those of the plains, although fewer in number", and notes that "the formation of artificial pastures could promote in the temperate and cold parts of the country a development of animal industry on a scale hitherto undreamt of". (Pittier, 1926, pp. 35 and 52.) In a later publication he writes that "in the zone

situated above 1,000 metres nearly all the forage grasses of the temperate zone and probably various classes of clover would be successful, at all events if properly cultivated". (Pittier, 1939.)

The savannahs of the lower mountain slopes are nearly always found as islands surrounded by forest, rarely at altitudes above 1,800 metres. Their very varied flora is composed principally of grasses, with an abundant admixture of legumes, species of the Compositae and Cyperaceae. The transition from these savannahs to the adjacent forest is more or less gradual and shrubs such as *Roupala complicata* and *Oyedaea verbesinoides* sometimes break their monotony. (Pittier, 1939.)

GUIANA HIGHLANDS

It has been suggested by James that the Guiana Highlands in the south might well be of special interest to the grazier. They consist of rounded hills and narrow valleys, with groups of flat-topped, sandstone tablelands in the extreme south towards Brazil, and they are covered with intermingled savannah and semi-deciduous forest. The grassy openings are extensive and very irregular in outline. As in the Orinoco plains, the year is sharply divided into a rainy season and a dry season, but the hilly nature of the terrain reduces the area subject to floods and the forest cover reduces the surface run-off. Physically the Guiana Highlands might be better suited for use as grazing land than the savannah-covered plain north of the Orinoco. (James, 1941.)

The region comprises approximately 150,000 square miles and is, on the whole, little explored. (Coiner, 1945.) Recently, however, ascents have been made of the highest tablelands, Mounts Roraima (2,810 metres), Duida, and Auyantepui (2,400 metres), and an account of the flora has been given in reports of the scientific expedition which visited the last-named mountain. (Tate, 1938; and Gleason and Killip, 1939.) Savannah fires, said to be wantonly kindled, and driven up the slopes by the strong south-east trade winds, have annihilated about four-fifths of the vegetation, and most of the south slope from 1,500 to 2,000 metres carries shrubby or herbaceous second-growth flora. The prevailing savannah of the region is grassy and treeless, but above 1,100 metres no true savannahs were found. The material collected included five species of *Panicum*, two of them new species, a new species of *Paspalum*, and a species of *Thrasya*. A relatively high degree of endemism is exhibited. An earlier account of the botany of Roraima was given by Im Thurn in 1887. (Thurn, 1887.)

Although in it the forest aspect of the region is stressed, W. H. Hudson's *Green Mansions* furnishes an incomparable popular description of this region. (Hudson, 1904.)

Since savannah does not appear to ascend above 1,100 metres, the Guiana Highlands can hardly be described as cool mountain grazings, and represent a transition type. Their remoteness and inaccessibility constitute a serious disadvantage.

GRASSES IN RELATION TO ALTITUDE

Pittier has made interesting studies of the altitudinal distribution of the Venezuelan plants (1926, 1937 and 1939), and more recently one of his students, now agrostologist to the Venezuelan Ministry of Agriculture, has published a tabulated account of the altitudinal distribution of the Venezuelan grasses. (Lucas, 1942*b*.) Of these grasses 112 genera and 441 species have been recorded up to the present, and those recorded for the lower zones are much more numerous than those found in the higher, but "this disparity", it is noted, "may be apparent only and due to the circumstance that the lower altitudes have been more fully explored". Of the few immigrants, several have become completely naturalized, examples of these being *Melinis minutiflora*, introduced about 1860, and *Tricholaena repens*, more or less recently introduced and now distributed from the hot to the frozen lands. Some species such as *Paspalum conjugatum*,

Setaria geniculata and *Hypparrhenia hirta* are found in every zone. In the uppermost zones most of the genera recorded are immigrants from the north and a few from the south, following the Andean ranges. Among these are *Festuca*, *Bromus*, *Helleria*, *Poa*, *Cortaderia*, *Agrostis* and *Calamagrostis*, but very few of the Paniceae and Andropogoneae.

Lucas records for altitudes of 1,000 metres and upwards (temperate to cold) the following numbers of species for the various tribes: Bambuseae, 12; Festuceae, 27; Hordeae, 7; Aveneae, 4; Agrostideae, 66; Zoisieae, 14; Phalarideae, 2; Oryzeae, 1; Zizanieae, 1; Melinideae, 4; Paniceae, 128; Andropogoneae, 46; Tripsaceae, 2. (Lucas, 1942b.)

Chase has noted that the introduced Brazilian grass *Melinis minutiflora* is being planted in reforestation experiments in the Andes up to 6,500 feet. (Chase, 1944.)

NUTRITIVE VALUE OF SOME GRASSES

In a monograph on the genera of the Venezuelan grasses, the morphology and taxonomy of which are studied, Lucas has included some notes on the history, distribution and economic value of certain species. A few are quoted here as of possible interest.

Of the two species of *Bromus* recorded for Venezuela, *B. pitensis* and *B. catharticus*, the latter is a native of South America, grows in temperate regions and is cultivated also as a good forage plant. Only three species of *Festuca* are known, none of which are of much economic importance. There are two *Poa* species, *P. annua* and *P. trachyphylla*, which, like the other species of this genus, are considered good forage.

Triticum aestivum, wheat, introduced from the Old World, was cultivated in both hot and temperate lands in the colonial epoch but is restricted to-day to the temperate and cold regions of the Andes. The only species of *Trisetum* recorded is *T. deyeuxioides*, which grows in the mountains at about 3,000 metres but is sparsely distributed.

Eight species of *Calamagrostis* are listed, all good forage where accessible to animals, but in Venezuela they grow in the high mountains and are not very common. The same is true of the nine species of *Agrostis* recorded. *A. perennans* is the most common. One species of *Alopecurus* is recorded, namely, *A. aequalis*, good forage but very rare.

There are three species of *Stipa*, namely, *S. ichu*, endemic of the Andes and the commonest, which affords good forage in the Andean grazings, *S. mexicana* and *S. mucronata*, all growing at very high altitudes.

Sixty-two species of *Paspalum* are enumerated, all reputed to be good forage plants. *P. notatum* and *P. lividum* form hill grazings.

The 58 Venezuelan species of *Panicum* are for the most part readily grazed wherever they grow in abundance, and some are of excellent feeding value. *P. purpurascens* grows from sea level to an altitude of 1,500 metres and is good for fattening cattle, although it is said to produce a somewhat puffy meat, not of very good quality. (Lucas, 1942c.)

PRESENT TRENDS

Although animal husbandry in Venezuela has passed through periods of decay, the very prodigality with which Nature has provided natural pastures constituting an obstacle to scientific development, the present epoch is marked by steady improvement and much progress, especially in dairying. With the introduction of better breeds of cattle the necessity of obtaining better herbage has become urgent. (Pittier, 1926 and 1939.) The present Ministry of Agriculture is encouraging the investigation of forage resources, and in addition to the appointment of an official agrostologist, exploration and trials in various parts of the country have been initiated. The work is said to look very promising. (Chase, 1944.) The favourite forage legume, *Medicago sativa*, does not appear to find favourable conditions in Venezuela, but many other legumes and nearly all the grasses of the temperate zone are successful under cultivation, for which purpose the uplands are likely to prove of most value. (Pittier, 1939.)

TYPE 2. COOL MOUNTAIN GRASSLANDS

(d) The mountain grazings of western Argentina and southern Chile

(i) Argentina

In Argentina hill grazings are to be found not only in the Andean range proper, but also in the smaller ranges of some of the western provinces. An account of two examples of these, found in the Province of Catamarca, has been published recently by Parodi. (Parodi, 1942b.)

SIERRA DE AMBATO .

Up to an altitude of 1,100 metres the plant cover is "monte" or scrub woodland, among the shrubs and trees composing which there are found xerophilous grasses characteristic of the Chaco such as *Trichloris pluriflora*, *Stipa ichu*, *Pappophorum elongatum*, *Setaria argentina*, *S. fiebrigii*, *Gouinia latifolia*, and typical mountain species such as *Stipa polyclada*, *S. leptostachya*, *S. pampagrandensis*, *S. cordobensis*, *Aristida achalensis* var. *elongata*, *A. subulata*, *A. adscensionis*, *Lycurus alopecuroides*, *Cottea pappophoroides*, etc. At 1,400 metres the silvery growth of *Stipa ichu* appears in an almost pure stand, whitening the slopes, and interspersed among the vegetation isolated small trees of the species *Prosopis nigra*, *Lithraea molleoides*, *Acacia cavenia*, *Lippia lycioides*, *Celtis spinosa*, etc., give it the character of a savannah. On the banks of rivulets large colonies of *Cortaderia rudiuscula* are commonly seen, distinguished by beautiful pale violet panicles. This *Stipa ichu* savannah covers the slopes and crests of the hills up to 1,600 metres, frequently exceeding 1,650 metres and sometimes covering slopes having a gradient of 45°, in association with various other typically mountain species such as *Stipa cordobensis*, *S. pampagrandensis*, *Aristida subulata*, etc. In some parts the *Stipa ichu* association appears almost interminable and presents so pure an appearance that it gives the impression of a culture. Parodi's tour was made in February, one of the driest months of the year, and it is noted that it would be desirable to survey these hill crests at various times of the year, notably in the spring. From the summer aspect, they appear to be almost entirely covered by the *Stipa ichu* association with scattered trees and to constitute a true savannah, notwithstanding the fact that grasses of the Paniceae and Andropogoneae tribes are rare because of the dry climate and the not very high summer temperatures. The typical savannah character, however, is evidenced in being dry in winter and growing during the rainy season of spring and summer.

SIERRA DE ANCASTI

Ascent was made on the western side, which is arid, with a steep scarp slope and sparse vegetation. At 1,500 metres there were observed *Stipa ichu*, *S. pampagrandensis*, *Diplachne dubia*, *Trichachne friesii* [*Trichachne penicilligera* ?], *Aristida adscensionis*, *Cottea pappophoroides*, *Briza stricta*, *Bouteloua aristidoides*, *Panicum molle* [*Panicum purpurascens* ?], *Flourensia campestris*, *Zinnia peruviana*, *Schkuhria pinnata*, *Solidago chilensis*, etc. At 1,750 metres this vegetation disappears almost entirely and is replaced by a grass steppe which covers the gently undulating summits of the hills at 1,800 metres. The somewhat compact, sandy soil is covered to approximately 70 per cent by the herbaceous growth forming the steppe; the surface is generally broken by rain-produced erosion. The characteristic plant species is *Festuca hieronymi* associated with *Stipa tenuissima*, *Muehlenbergia circinnata*, *Eragrostis lugens*, *E. virescens*, *Piptochaetium napaostaense*, *P. chaetaphorum*, *Schkuhria pinnata*, *Hysterionica bakeri*, *Oxalis* sp., *Sisyrinchium* sp., etc. Crossing this broad summit from west to east, there is entered at an altitude of 1,600 metres a savannah of *Stipa tenuissima* with small, isolated trees of *Prosopis nigra* and *Iodina rhombifolia*, the shrubs *Condalia lineata* and *Cestrum parqui* distributed in more or less extensive patches, and tufts of *Festuca hieronymi*, *Stipa ichu*, etc. This undulating land, which slopes gently towards

the east, extends for many leagues, the whole landscape whitened by *Stipa ichu* and *S. tenuissima*. Descending the eastern slopes, tree growth begins to appear at 1,500 metres, becoming closer the further one descends.

The grassland of the summit is used for the rearing of cattle and sheep, but, being lightly stocked, is in a good state of conservation.

In ascending the same range at another point, tree growth was observed to terminate almost abruptly at 1,400 metres in a slightly undulating plain covered with a savannah of *Elyonurus tripsacoides* with very scattered shrub growth (*Gourliea decorticans*, *Acacia* spp. and *Eupatorium*). *Elyonurus tripsacoides* is found here in a practically pure stand, resembling in appearance ripe wheat fields of the province of Buenos Aires. At Singuil (1,550 metres) the tree growth of the "monte" or scrub woodland has almost entirely disappeared and a rich grass flora begins in which *Festuca hieronymi* abounds, associated with *Stipa ichu*, *Elyonurus tripsacoides*, *Paspalum elongatum*, *Panicum bergii*, *Eragrostis lugens*, *Bouteloua curtipendula*, *Baccharis coridifolia*, *B. gillesii*, *Lathyrus macropus* and great tufts of *Cortaderia rudienscula* on the banks of rivulets. Further to the north-east, at approximately 2,000 metres, the hilltops are covered by an extensive xerophilous coarse grass sward composed for the most part of *Festuca hieronymi*, *Stipa tenuissima*, *Aristida spegazzinii*, etc. The western slopes of these hills are drier, less grassy, and treeless. Descending to 1,700 metres, there is found in a wide, gently undulating valley a xerophilous herbaceous vegetation in which *Muehlenbergia gracillima* [*M. nardifolia* ?], *Pappophorum mucronulatum*, *Aristida subulata*, *Eragrostis lugens*, *Evolvulus* sp., *Baccharis gillesii*, predominate. The two first-named grasses form, almost by themselves, a close sward which, in spite of its inferior quality, is useful for fodder in the lack of better herbage. (Parodi, 1942b.)

The above may be taken as typical examples of Argentine hill grasslands.

HILLS OF TUCUMÁN, CÓRDOBA AND SAN LUIS

Similar steppes are described by Frenguelli (1941) for the tablelands of the ranges of hills that flank the western limits of the pampas in the Argentine provinces of Tucumán, Córdoba and San Luis. Hard grasses predominate, large or small, perfectly bare patches of rocky or stony soil always visible between their tufts. In the hills of Tucumán they lie between altitudes of 2,500 and 3,000 metres, covering upland plains and gentle slopes with a sward in which grasses (*Calamagrostis rosea*, *C. polygama*, *Festuca hieronymi*) predominate, but an abundance of other plants is also present, including *Lupinus prostratus*, *Trifolium matthewsi* and *Dalea onobrychioides*. Analogous steppes are found in the Sierra Grande of Córdoba from 2,000 metres upwards, the most notable being that of the high plateau known as the "Pampa of Achala". It is composed of tall clumps and more or less isolated tufts of hard grasses (*Poa stuckertii*, *Stipa*, *Bromus*, *Festuca*) interspersed in the higher parts with herbaceous species such as *Cerastium nutans* var. *argentina* and others and in moister places with *Carex bonariensis*, *Alchemilla pinnata* (already determined by Ringuet, 1941 and 1942, to be a good forage plant), *Trifolium matthewsi* and others. (Frenguelli, 1941. Parodi, 1945c.)

THE PUNA

The xerophilous shrub steppe known as the Puna that is found on the great highland plain which, from the adjacent zones of Chile and Bolivia, penetrates north-western Argentina through the province of Jujuy and the Territory of The Andes, and covers also the high, arid ranges of the provinces of Jujuy, Salta, Catamarca and La Rioja, does not come under consideration here; it belongs rather to the arid grazings of Type 3, and much of it comprises vegetation of the páramo type. The climate is arid subtropical; the average annual rainfall is less than 250 mm., distributed

over 20 to 50 summer days (October to April), and although the average temperature ranges from 10° to 14° C. the daily oscillations are wide, intense cold at night alternates with strong insolation by day. The snow line lies above 4,500 to 5,000 metres. (Frènguelli, 1941.) The flora is extremely poor. Characteristic grasses are hard-stemmed species of *Festuca*, *Calamagrostis* and *Stipa*. (Vellard, 1939.) At present a constant shortage of meat and milk is recorded for the north-western provinces of Jujuy, Salta, Catamarca and La Rioja. (*Noticioso*, Buenos Aires. 10th Oct., 1944.)

(i) Southern Chile

SOUTH ANDEAN GRASSLANDS

It is probably otherwise, however, with the Andean grasslands of south-western Argentina, when these exist among the forest. On the western, Chilean side of the Andes, grazings of the highlands of Magallanes are composed of the following plants, among others: an herbaceous plant with creeping rhizomes, closely resembling the *Festuca acanthophylla* of the Andean lands of central Chile and furnishing rather coriaceous herbage; *F. purpurascens*, excellent forage; *Bromus stamineus*, perennial, caespitose, attaining a height of 60 cm., common; *B. coloratus*, *B. catharticus*, *Hordeum chilense*, *Alopecurus antarcticus*, *Vicia patagonica*, *Empetrum rubrum*, a much-branched shrub about 50 cm. high; and *Ugni molinae*, a shrub of up to 2 metres in height, with dense foliage and very fragrant flowers and fruit. (Opazo, 1939. Vol 3.)

TYPE 2. COOL MOUNTAIN GRASSLANDS

(e) The upland pastures of the central plateau, Costa Rica

ANIMAL INDUSTRY

There are various reasons why the animal industry of Costa Rica is of interest. In the first place, the stock-raising tradition here is extremely ancient. Coronado, approximately in 1564, "envisaged the alluring tablelands as a realm of Spanish homesteaders. For the use of the new colonists he introduced horses, cattle and swine to take advantage of the rich stores of highland grass. Thus in the central plateau of Costa Rica were established some of the earliest cattle ranches of the New World." (Wilson, 1942.) In the second place, the quality of the cattle raised (and used practically entirely for home consumption, although hides and skins are exported) is being gradually improved in quality by crossing with Brahman, Hereford or other imported breeds. (Becker, 1943.) Wilson, indeed, affirms that Costa Rica "is one of the few tropical sources of presentable beef and dairy cattle". (Wilson, 1942.) Again, Costa Rica is a peaceful, progressive and vigorous country; the percentage of illiteracy is one of the smallest in all Latin America, the population is on the increase. "The Costa Ricans have built a state which is notable for its coherence and for the orderliness of its economic, social, and political life". (James, 1941.)

CLIMATIC AND AGRICULTURAL ZONES

Costa Rica, which, as part of the isthmus connecting North and South America, has a Caribbean as well as a Pacific coastline, is made up of a chain of highlands extending from north-west to south-east, higher in the southern part, the whole flanked on the north-east by lowlands narrowing to the south. In the centre of the highlands, located between the slopes of the south-western mountain range and a row of four great volcanoes lying to the north-east, 3,000 to 4,000 feet (915 to 1,220 metres) above sea level, in the temperate climate, is the Meseta Central or central plateau. This plateau (which, strictly speaking, is an intermont basin, a structural depression deeply filled with volcanic ash) comprises the core of Costa Rican life; here and in the surrounding highlands 76 per cent of the population of 600,000 live. (James, 1941.)

There are two seasons, the dry season or winter, from December to April, and the wet season or summer, from May to November. The temperature varies from tropical heat on the coasts to warm summer in the interior, the mean temperature at 3,000 to 6,000 feet (915 to 1,830 metres) ranging from 57° to 68° F. (13.9° to 20° C.). (South American Handbook, 1941.)

SMALL HOLDINGS OF THE UPLANDS

In the central highlands, where over 90 per cent of the population are of unmixed white ancestry, land use differs from the traditional large landowner and small tenant system that is characteristic of the rest of Latin America, for in Costa Rica most of the land is owned and worked by small farmers. (James, 1941.) The extensive ranch system, therefore, is uncommon in these lands, and the highlands are unable to cover their own considerable requirements in meat. These are supplied largely by the ranches of the lowlands, notably of Guanacaste in north-western Costa Rica, which in 1939 had more than 40 per cent of the cattle in the country. (Becker, 1943.)

HERBAGE OF THE UPLANDS

Nevertheless the climate and plant cover of the highlands appear to be more suitable for stock raising. Wilson writes that "rough hill lands and some of the tallest of Costa Rica's mountains are closely covered with luxurious grasses". (Wilson, 1942.) Pittier, writing on the possibility of improving grasslands in the higher regions of Venezuela, mentions "incomparable alpine pastures" that had been established on the slopes of the Costa Rican volcanoes Irazú and Turrialba, situated north of the central plateau. (Pittier, 1926.)

Standley, in a survey of the vegetation of Costa Rica, says that "great parts of the *tierra fría* [cold region] have been cleared for cattle pastures. After the trees were felled, the land was sown with grass seed, usually of European origin, and as a result the pasture flora is more European than American. The forage grasses are European, and with them are naturalized European plants like *Trifolium repens*, *Lotus*, *Bellis perennis*, *Silene gallica*, *Ranunculus*, *Veronica*, *Taraxacum*, *Digitalis*, and many more". (Standley, 1945.)

Wilson, of course, refers to the natural plant cover, Pittier and Standley to pastures established by purposeful management.

Although the highlands of Costa Rica are largely occupied by cash crops such as coffee and by subsistence crops such as maize, there would appear to be scope for a development of the animal industry, and attention is being paid by the National Centre of Agriculture to certain aspects of the question. The Botany Section is making a study of plants (a) toxic to animals, (b) observed to be sought by animals as fodder, in which connexion notes are presented on *Galinsoga parviflora*, a valuable forage and hay plant; on a branched, biennial rape of which trials have been made and which is considered to be very promising for Costa Rican conditions; and on the following indigenous and introduced legumes: *Desmodium intortum*, *D. adscendens*, *Lathyrus grandiflorus*, *Vicia villosa* (introduced by the Centre), *V. sativa* (introduced in wheat seed), *Medicago arabica* and *M. hispida* var. *denticulata* (both introduced), *Pachyrrhizus erosus*, *P. palmatilobus*. (Orozco, 1939.)

The Government Agricultural Experiment Station at Birrisito, situated at an altitude of 1,500 metres in a temperate climate subject to Atlantic influence, is studying the regional types of agriculture, among which grazing in planted pastures is characteristic of the laterite soils. The favourite grass for this purpose is *Melinis minutiflora*. (Esquivel, 1941.)

Hodgson and Dahlberg, discussing the natural resources of Costa Rica in relation to the dairying industry, have listed the principal grasses (twenty-three) and legumes (five) used as herbage in the various parts of the country. Most of the species are indigenous. Little has yet been done to

enhance their productivity or quality, and it is suggested that trials should take place at different altitudes to determine which are the most valuable in regard to yield, nutritive value, development and adaptability in mixtures, resistance to drought, lateness in ripening, and other characters. (Hodgson and Dahlberg, 1945.) Maroto has also published a useful synopsis of twenty-seven grasses grown in Costa Rica, showing the region in which each is grown, its purpose, the soil required, method of sowing or planting, the number of cuts obtainable, duration, palatability, and coefficient of digestibility. (Maroto, 1945.)

TYPE 2. COOL MOUNTAIN GRASSLANDS

(f) The páramos

THE FORMATION

A word should be said here about the páramos, which are swards of low-growing plants, largely of the rosette and cushion type, found at very high altitudes in the Andes between the limit of forests and the snow line. Beard is of opinion that the Spanish term "páramo" is preferable to the sometimes used "alpine meadow", in order to distinguish the purely tropical American formation, but suggests that if an English term is preferred, "Andine meadow" might be employed. (Beard, 1944.)

Pittier, the Venezuelan botanist, describes the formation as follows: "At variable altitudes, but never much below 1,800 metres, the upper edge of the forests becomes gradually stunted and then passes into the formation of the páramos. In its usual context, páramo means a cold desert, swept by violent winds and not seldom beaten by tempests of snow and hail which may threaten the lives of travellers. In our Andes, while these storms and their attendant risks are not lacking, the expression is applied to the most elevated parts, almost entirely devoid of woody vegetation and covered mostly with stemless plants having enlarged root-systems and coriaceous leaves, arranged usually in basal rosettes and protected against the rigours of the climate by means of various adaptations. In proportion to their size, many of the plants have large and showy flowers, in such a way that the páramo at the flowering season is comparable up to a certain point with any alpine meadow." (Pittier, 1939; trans. Beard, 1944.)

PLANT COVER

For central and south-eastern Peru this formation has been fully described by Weberbauer (1936) under the name of "puna", a general term given in that country to the region lying above the limit of agriculture and used by Weberbauer almost in the same sense; "it ends below at 3,800 to 4,000 metres, and above on the highest summits".

Penland has published a short, illustrated account of the Andean páramo of Ecuador. "Over most of its extent it is marked by a cover of several species of grasses of the bunch form. In these there appears to be growth throughout the year. Among the living shoots there is always a high proportion of dead ones, which gives a yellowish-brown or olive-brown rather than a green colour to this grassland as a whole. One is constantly reminded that the páramo is perpetually under the influence of a fall, or an early spring season." "The practice of the natives of burning the grasslands in order to make the young shoots available to their grazing livestock has undoubtedly done much to modify the extent and composition of this zone." The grasses are said to be "chiefly species of *Calamagrostis* and *Festuca*". (Penland, 1941.)

Writing of the highland vegetation of the Venezuelan coastal range on the shores of the Caribbean Sea, Pittier says it is probable that these swards also constitute páramos and they certainly have some species in common with the Andean páramos, but in floristic composition they are incomparably poorer than the latter, which are stated to be very rich in species notable for the

beauty of their flowers. There are given as examples *Hypericum brathys*, *H. laricifolium*, *Geranium* spp., *Potentilla heterosepala*, and others. "Among the pygmy plants of the páramo proper, *Aciachne pulvinata*, a grass with piercing leaves, forms a continuous sward interspersed here and there with minute plants having large flowers, such as *Malvastrum acaule* and *Hypochoeris setosa*. . . . But it is in parts where the soil is richest and in the gullies where the most spectacular plants of the páramo are found, namely, the lupins, *Lupinus ramosissimus*, *L. jahnnii*, *L. roseus*, with foliage having the leaflets arranged in the form of a star and the pink or blue flowers growing in elegant spikes, and especially the *Espeletia* species." (Pittier, 1939.) Heilborn records *Lupinus alopecuroides* for the páramos of Pichincha, Ecuador. (Heilborn, 1925 and 1943.)

Sandwith (1941), in a study of plants collected in the páramos of Venezuela and Colombia, recorded the collection of *Lupinus meridanus* on Venezuelan páramos and of a new species which he identified as *L. verbasciformis*, found growing at 4,000 metres, rare, among herbs, grasses and undershrubs, in close association with *Espeletia* spp. Of the tussock-forming grass of the páramos, *Aciachne pulvinata*, Agnes Chase writes: "This tiny grass, endemic of the páramos from Venezuela to Bolivia, growing on windswept heights, has achieved dominance by extreme reduction. Its stems are but 1 to 2 inches tall, its stiff rolled leaves about a quarter of an inch long, and its inflorescence usually reduced to a single 1-flowered spikelet. The horny floret tightly encloses the stamens and pistils, the flower being self-pollinated—no pollen wasted in the wind. The needle-tipped florets attach the ripe seeds to any passing animal, and the strong winds also distribute the seed." (Chase, 1944.)

GRASSES OF THE PÁRAMOS

A recent study of the altitudinal distribution of the grasses in Venezuela (Lucas, 1942b) has shown that an astonishingly large number of the 441 species hitherto recorded for that country grow in the so-called cold lands (2,800 to 3,800 metres) and even in the frozen lands (3,800 to 5,000 metres). The páramos are found mainly in these zones, and in considering their value as grazings the following list of species recorded by Lucas may be of interest. (The letter "c" indicates the cold lands, "f" the frozen lands.)

Arthrostyliidium geminatum (c); *Bromus catharticus* (c); *B. pitensis* (c, f); *Helleria fragilis* (f); *Festuca australis* (c); *F. myuros* (c, f); *F. tolucensis* (c); *Poa annua* (c, f); *P. trachyphylla* (c); *Cortaderia bifida* (c, f); *C. nitida* (c); *Triticum aestivum* (c); *Lolium temulentum* (c); *Trisetum deyeuxioides* (c); *Danthonia secundiflora* (c); *Calamagrostis bogotensis* (c); *C. coarctata* (f); *C. effusa* (c, f); *C. heterophylla* (f); *C. intermedia* (c); *C. longiaristata* (f); *C. pittieri* (c); *C. planifolia* (c, f); *Agrostis breviculmis* (f); *A. haenkeana* (c, f); *A. perennans* (c, f); *A. pittieri* (f); *A. trichoides* (c, f); *A. turrialbae* (f); *Cinna poaeformis* (f); *Alopecurus aequalis* (c); *Polygonum elongatus* (c); *P. interruptus* (c); *Muehlenbergia erectifolia* (c); *Aciachne pulvinata* (f); *Sporobolus brasiliensis* (c); *S. poiretii* (f); *Stipa ichu* (c, f); *S. mexicana* (c); *S. mucronata* (c); *Aristida adscensionis* (f); *Aegopogon cenchrionoides* (c); *Hierochloë mexicana* (f); *Digitaria sanguinalis* (f); *Paspalum conjugatum* (c, f); *P. macrophyllum* (f); *P. trianae* (f); *Tricholaena repens* (f); *Setaria geniculata* (c, f); *Pennisetum peruvianum* (c); *Trachypogon ligularis* (c); *T. montufari* (c); *Andropogon saccharoides* (c); *Hyperphenia hirta* (c, f).

ALTITUDE

The altitude of the páramos varies. Pittier, as quoted above, says that they are seldom found lower than 1,800 metres. James notes that in Colombia the area of the páramos lies between 10 and 15 thousand feet (approximately 3,050 to 4,600 metres). (James, 1941, p. 91.) Heilborn, in a study of the páramos of the volcano Pichincha, near Quito, Ecuador, gives the upper limit of the scrub as 3,650 metres and the snow line of the Ecuadorean Andes as 4,700 to 5,000 metres, although eternal snow is not characteristic of Pichincha. The páramos are found between 3,650 and 3,850 metres, and exhibit an abundance of grass growth in their lower parts. (Heilborn, 1925 and 1943.)

USE FOR GRAZING

Although Knuchel, writing of Peru, says that only sheep and the indigenous llamas and vicuñas are able to benefit from grazing at extreme altitudes such as 4,000 to 4,800 metres (Knuchel, 1943), the grazing of the páramos appears to be a fairly common practice. James records that the páramos of Colombia are used for grazing, and even for grazing cattle (James, 1941, p. 96 and 109); and in Ecuador, where grassy páramos cover about half the total area of the highlands, the original cover of dense brush having disappeared through exploitation for charcoal or through burning for pasture, they are also used for grazing. (James, 1941, pp. 127-8.)

Knoche, in giving an account of meteorological conditions at the Eagle Mine on the south-eastern flank of the Bolivian Andes, describes a plant formation of the páramo type, such as would be found in the European Alps at an altitude of 2,000 metres but growing here at approximately 5,230 metres, which he says is used by the Indians inhabiting the lower valleys for grazing their cattle the whole year round. The sward is described as composed of succulent herbaceous plants and flowers in great abundance and quantity of species. The cattle are said to suffer no inconvenience from the cold, the low atmospheric pressure and the intensely dry air, and it is remarked in parenthesis that the Vikings of the Middle Ages used to graze their cattle even in Greenland. (Knoche, 1944.) Wylie, on the other hand, writing of Colombia, reports that "the páramos cattle are very poor in quality, rickety and hairy because of the cold weather and poor pasture". (Wylie, 1942.)

The páramos appear to be more or less nutritive. One of their components, *Alchemilla pinnata*, has been the subject of special study in Argentina. It belongs to the family Rosaceae, and is a creeping hemicryptophyte found from the Andean lands of Peru and Bolivia to those of north-western Argentina. It constitutes small meadows, forming a low, close sod which is said to provide almost the only food of the numerous flocks of sheep grazing the high tablelands of these regions. The material studied was found in the Pampa de Achala at an altitude of 2,200 metres, and chemical analysis has shown it to be an excellent forage plant with a high content of phosphorus, potassium, magnesium and calcium. (Ringuelet, 1941 and 1942.)

IMPROVEMENT

Knoche recovered from a serious pulmonary affection as a result of his sojourn at the Eagle Mine, and suggests that localities such as this might well be utilized as health resorts. (Knoche, 1944.) If his suggestion were adopted, the existence in the páramos of grazings for dairy cattle and other animals would be an advantage. At the present time, although these lands appear to be utilized largely by the Indians, their value and the possibility of improvement are also recognized by the responsible authorities. In Colombia, for example, the experiment station of La Picota, near Bogotá, which is testing a variety of herbage plants, has noted that *Vicia villosa* can be grown at altitudes ranging from 1,360 metres up to the páramos at 3,600 metres, that *Pennisetum clandestinum* has already been grown successfully above 3,000 metres, and that *Dactylis glomerata*, introduced from the Old World, has been successful as high as 3,200 metres and has given excellent results in fertile volcanic soils of the central Cordillera in Colombia. (Abadia, 1943.) Popenoe, of the Pan-American Agricultural College in Honduras, is of the opinion that the introduction of a superior forage plant for the páramos would be of immense importance. (Popenoe, 1945.)

CHAPTER 5

THE NATURAL GRASSLANDS

TYPE 3. SEMI-ARID GRAZINGS

(a) Central and Northern Patagonia

THE REGION

The name Patagonia is not a political delimitation, but is applied to that region of southern Argentina which has more or less clearly defined natural boundaries and is characterized by cool temperatures, low rainfall and xerophytic vegetation. In the early days of discovery by the Europeans the name was given to the local Indians, and in course of time the region itself became known as Patagonia. Ball (1891) considered that "the name is properly limited to the southern part of the American continent lying east of the Andes, which is drained by streams running into the Atlantic Ocean", but he noted that the northern shores of the Straits of Magellan, although geographically a part of Patagonia, exhibit vegetation resembling that of the Fuegian archipelago rather than that of Patagonia, and considered that a line drawn somewhat south of the 52nd parallel would approximately represent the northern limit of the Magellanic flora. The northern boundary of Patagonia is fixed by him as the course of the river Colorado. Beetle (1943) confirms Ball's delimitation, giving the northern limit as occurring in the drainage areas of the rivers Negro and Colorado or between 41° and 43° S. The western and southern limits appear to be marked by vegetational boundaries, namely, by the sub-Antarctic forest of the Andean range on the west, and by the extent of the xerophytic influence on the vegetation to the south, just below the Rio Gallegos. (Beetle, 1943.)

SALIENT CHARACTERS

Very strongly marked characters distinguish the region from the rest of the continent, namely, its contour, with vast, flat-topped plateaux rising in steps from east to west, attaining a final height of over 5,000 ft. (1,525 metres) and intersected by deep canyons running from west to east, with or without swiftly running streams; its dryness; its rigorous, windswept climate; and the unusual poverty of its flora.

CLIMATE

An account of the climate of southern Patagonia which throws light on the climate of the whole region has been published by Fiorda (1940). The region studied here is situated between the parallels 50 and 52-22 S. and is limited on the north by the river Santa Cruz, on the east by the Atlantic Ocean, on the west by the Chilean frontier, which follows approximately the continental water divide, and on the south by an arbitrary line which, starting from the water divide, follows in part the 52nd parallel and then goes in the direction of Cape Virgenes, where it terminates. The cold southern climate is kept uniform by the proximity of the Pacific and Atlantic Oceans, no part of the interior being situated at a greater distance than 200 kilometres from the sea. Cold currents wash both the Pacific and the Atlantic coasts of southern South America.

The prevailing winds are from the west and west-south-west with variants from the south-west and north-west, and they blow with unusual violence and great frequency. In accordance with meteorological observations made at Rio Gallegos, the relative frequency of the winds on a scale of 1,000 (average for 22 years) is as follows:—

N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm
95	59	19	26	74	403	130	61	133

The mean annual figure for the maximum velocity of the wind during the years 1937 and 1938 is 88 km. per hour. The winds blowing continuously from the west to east, with great violence in the antarctic zone, affect in general the southern part of the continent as far north as the 40th degree of latitude, their effects being felt with greater intensity during the summer months.

The causes which determine the direction of these winds have not yet been sufficiently studied, for it is difficult to accept the theory, held by some, that it is a reaction produced by the effects of the movements of the earth in its rotation, since in the northern Polar zone no similar winds are recorded.

These winds, after having passed over a great surface of the ocean and becoming charged with moisture, arrive at the Pacific coasts, where they have to rise in order to pass the barrier presented by the Andean range, producing thereby the condensation of the greater part of the moisture they contain, which falls in the form of rain or snow on the western slopes of the Cordillera.

The continental barrier constituted by the Andes is interrupted on passing the 51st parallel, being abruptly cut by an arm of the Pacific Ocean running up into the Chilean territory. This arm of the sea, which is named Last Hope Inlet, completely cuts the Cordillera and reaches its eastern slopes. To the south of this interruption the range is much lower until it reaches the Straits of Magellan.

This factor has a very favourable influence on the zone to the south of the Santa Cruz zone, for it permits the passage of the moisture-laden clouds which are driven by the prevailing west winds, abundantly watering the region.

Farther to the north, where the Andean range attains a great height, the clouds which cross it leave in their passage the greater part of their moisture and the winds in descending from the heights rise in temperature and become dry, in consequence of which there is produced only a little isolated rainfall of short duration, and in many cases, on account of the height of the clouds, these rains have completely evaporated before they reach the ground.

On clear days during the summer, because of the dryness and the clearness of the atmosphere there is produced in the tablelands a heating of the air which, on expanding, rises, producing a partial vacuum. This vacuum, on being filled by the colder air coming from the Cordillera, accelerates the velocity and increases the violence of the prevalent wind.

The cold and dry hurricane winds, which sometimes blow for fifteen consecutive days with an intensity ranging from 60 to 120 km. per hour, keep the temperature of the ground low by producing an excessive evaporation, remove all the finer and lighter particles of earth, and deform plants by their continuous action in one direction.

The acute angle at which the sun's rays fall at every time of the year on account of the latitude, although more accentuated during the winter season, causes the solar radiation to arrive enfeebled. There is evidence of this in the valleys which run from west to east, where on the somewhat pronounced slopes that have a northern aspect there grows a completely distinct vegetation which does not find favourable conditions on the opposite side of the valley with a south aspect, where the sun's rays arrive at a more acute angle.

On account of the small quantity of moisture in the atmosphere, which means that the air in general is dry, radiation is not prolonged, and when the sun disappears the temperature falls abruptly. This same reason it is that causes the absence of dew, which is almost unknown in this zone.

On fine days the general clarity of the atmosphere, owing to the absence of particles of dust and moisture in suspension, helps to increase the benefits of the sun's action. These benefits are counteracted by cloudiness, for with great frequency the sky is covered with clouds, the days on which the sky is completely clear being very few.

There are many days in the year on which the sky is clear at sunrise, but after an hour the formation of "cirrus stratus" begins at a great altitude, thin at first but later becoming denser and obstructing the light of the sun. When this occurs, after sunset these clouds are nearly always completely dissipated, the night remaining clear.

Rainfall, according to the data of the Meteorological Office of Rio Gallegos (mean of 3 years), is 230 mm. This fact is enough for the zone to be classified as arid, but again it has to be taken into account that Rio Gallegos is situated in the extreme south-east of the zone in the proximity of the sea, for which reason rainfall there is much greater than at many points in the interior. On the other hand, in the part adjacent to the Chilean frontier in the south-west region towards Cancha Carreras, rainfall is greater than at Rio Gallegos, this being the factor which allows the growth of forest in that part.

The high plateaux which constitute the northern and central parts of the zone are some 50 km. to the west of the Atlantic coast, and for this reason removed from the influence of the ocean; they are limited on the north by the valley of the river Santa Cruz, on the south by the valley of the Coyle, and on the west by the Sierras Baguales. In these plateaux rainfall is much less than in the rest of the zone, as a consequence water is scarce and comes almost exclusively from the snow which falls during the winter, the greater or lesser quantity of which regulates the growth of herbage during the summer.

In the higher plateaux the winter is long and very cold, the temperature falling sometimes to 35° C. below zero and the soil freezing to a depth of 80 cm. During the spring and summer morning frosts are very frequent, sometimes lowering the temperature during these seasons to 10° C. below zero.

The manner in which thawing takes place in the spring has a considerable influence on the growth of the herbage and on the land in general. During the month of May the temperature falls, the ground freezes and the snow that falls during the winter remains on the ground, forming successive covers which are sometimes partially melted.

During the months of August, September and October thawing takes place. When this happens gradually, the water penetrates the ground beneficially. But this very seldom occurs, for generally the temperature rises abruptly by several degrees and is accompanied by winds of extreme violence from the west-north-west quarter which last several days, and the snow and ice accumulated during the winter, melting rapidly, form torrents that carry away with them the humus and organic residues of the soil, which are borne out to sea by the rivers. As there are no wide plains on which the overflow of the rivers can spread and deposit the silt brought down in suspension, but, on account of the gradient, the rivers run swiftly and unhindered to the sea, all this material is irretrievably lost. (Fiorda, 1940.)

While the foregoing refers especially to a limited section of Patagonia, much of what has been said is probably true of the whole central and northern region.

In Hardy's rainfall map of South America (F. Hardy, 1942, after C. F. Jones, 1928) the rainfall of Patagonia is given as 0 to 10 in. (0 to 254 mm.), and the July temperature or that of the southern winter as ranging from 40° to 48° F. (4.4° to 8.9° C.). In his soil map the lands of Patagonia are classified as gray desert. Fiorda (1940) records a deficiency of humus, and from his study of the existing vegetation and of lake shores concludes that a process of accelerated desiccation is taking place which threatens to transform the land into an unproductive desert within a relatively short lapse of time. Hardy's vegetation map (from Philip's Atlas, 1937) shows the area to be occupied by thorn scrub steppe.

THE PLANT COVER

The Patagonian flora is remarkable for its exceptional degree of poverty. Ball (1886 and 1891), who gave the mean annual temperature of northern Patagonia as 59.4° F. (15.3° C.), considered that neither this temperate warmth, the sterility of the soil (since soil sterility is in general favourable to the development of new plant forms), nor even the dryness of the climate, can be held accountable. His opinion was that the flora is poor, not because the region cannot support a richer one, but because for this young land, raised from the sea during the latest geological period, the only regions from which a large population could be derived are inhabited by races unfit for emigration. "The rapidity with which many introduced species have spread in this part of South America is perhaps to be accounted for less by any special fitness of the immigrant species, than by the fact that the ground is to a great extent unoccupied." If this be so, the introduction of hardy, new species of herbage plants should be no very difficult matter.

A full description of the phytogeography of Patagonia was published by Hauman in 1925, but space permits reference to only a part of this. In describing the plant associations of the steppe, Hauman distinguishes between the flora of the valleys leading up from the coast to the plateau, that of the plateau proper, that of the depressions, the "vegas" or moister meadowlands and river and lake shores, and the halophyte flora of certain areas. Of the plateau proper he writes: "On the perfectly horizontal, stony, windy plateau, receiving only rare and low rainfall, with long and rigorous winters, nothing but an extremely sparse vegetation can develop, a vegetation not only xerophilous but more often than not adpressed to the ground or, if at all raised from it, with very reduced or coriaceous leaves. The shrubs disappear almost entirely: the *Berberis* species (*B. buxifolia*, *B. heterophylla*), abundant in the valleys and found again, more vigorously developed, in the Precordillera, are here relatively rare, stunted, and, in particular, rarely fertile, and there only remain two, absolutely characteristic species which rarely exceed 50 cm.:

Verbena tridens and *Nardophyllum kingii*. Their abundance is, however, very variable and one can sometimes travel for entire leagues without encountering either. . . .

"In order of diminishing height, there must now be mentioned the grasses, the individual abundance of which varies much by reason, perhaps, of the destructive action of sheep and which are for the most part rather rare. In the most typical parts they may be represented by some dwarf specimens of *Bromus macranthos*, *B. unioloides* (*B. catharticus*), *Danthonia picta*, *Poa* aff. *bonariensis*, *Trisetum subspicatum*; but where the terrain is a little less stony, and especially on somewhat sheltered slopes, there abound dense, narrowly conical tufts of *Stipa humilis*, *St. patagonica*, or of different sharp-leaved *Festuca* species, all having filiform leaves, yellow from the end of the spring onwards and perpetually agitated by the wind. The elegant panicles of *St. neaei* and *St. pogonantha*, on the contrary, frequently emerge from shrubs, the branches of which protect and support their delicate stems, while their long, feathery awns sway above, in constant motion from the wind.

"Much less visible and still more modest are the elements which constitute, however, the wealth and the considerable interest of the plateau flora; an extraordinary variety of dwarf plants, herbaceous or more often ligneous, some acaulous and of rosette habit, others, more numerous, with multiple but very short stems or perhaps with climbing stems. If the climbing stems are much branched or, as happens more frequently, if the short stems or the rosettes accumulate and are pressed one against the other, there are formed the dense carpets or the more or less hard and convex cushions which constitute, in my opinion, the characteristic feature of the Patagonian vegetation."

Having discussed these last-named types of plant, he continues: "The flora of the Patagonian steppe may, then, be described as follows: a vegetation xerophilous in the extreme, discontinuous and disseminated among the shingles of the plateau, where the grasses play an entirely secondary role; very rich in species and formed for a large part of low, rosette plants, in swards or in cushions, often almost muscoid in spite of their ligneous consistency and their powerful roots, and overtopped only by some shrubs with reduced or coriaceous leaves.

"To these characters yet another must be added: the extraordinary monotony of the landscape. It was only after travelling 250 kilometres from the coast, on the eighth day of our long journey, when the little valleys of the Precordillera began and from the tops of the hills one could see in the distance the brilliant, mirror-like surface of Lake Argentino, that the plant cover began to be modified a little." (Hauman, 1925.)

IMPORTANCE OF SHRUBS

Beetle (1943) discusses the origin of the Patagonian flora at some length. Ball (1886) gives an interesting table of the proportions, in percentage of the whole flora, in which the chief natural orders are represented in northern Patagonia, and the Compositae, with 36 species and a percentage of 18.65, hold pride of place, followed by the Gramineae, with 30 species and a percentage of 15.5. The percentage of Leguminosae is very small, only 4.1. Davies (1940), in describing the shrub steppe of the Patagonian desert, says: "Taking the area as a whole, the grass flora is sparse; in some cases there is practically no grass, or indeed any vegetation at all (other than an ephemeral one after heavy rains) at ground level". He notes that the bushes of the scrub cover are sometimes only scattered, and sometimes fairly densely placed, but the cover is usually open enough to permit one to walk between the bushes with ease. Beetle (1943) notes that the shrubs are tall in northern Patagonia but rapidly dwindle southwards, and that they are composed predominantly of species of the Compositae or of the Leguminosae (for example, *Prosopis strombulifera* and *Cassia aphylla*).

The shrubs of central and northern Patagonia are all-important for the pastoral economy of the region, because it is upon their leaves and shoots that the grazing animal chiefly depends for

sustenance. They appear to be much more succulent and palatable than the sparse grasses, which are fibrous, dry and stemmy.

USE

Soil and climate alike indicate stock raising as the natural form of land utilization in central and northern Patagonia, and the hardy sheep as the most profitable type of stock, although a few cattle also are kept. It is only the enormous size of the area, however, comprising practically the whole of the territories of Rio Negro and Chubut as well as the northern part of Santa Cruz, which permits the raising of so large an animal population as is actually produced, for the carrying capacity per acre is low, on an average one sheep to 12 to 15 acres (4.86 to 6.10 hectares). (Davies, 1940.)

HERBAGE

Earlier botanical surveys of the region have been mainly of an exploratory and floristic nature. For a list of such works, apart from those already mentioned, reference is made to Castellanos and Pérez-Moreau's botanical bibliography of Argentina (1941) and to Blake and Atwood's "Geographical guide to the floras of the world" (1942). Recently, however, surveys of representative areas of Patagonia and other parts of Argentina have been made by W. Davies which are of especial interest as being from the viewpoint of an agrostologist (Davies, 1940). While it is not possible within the scope of the present study to do more than indicate the availability of these surveys, it may be noted that they confirm the poverty of Patagonian plant species already recorded by previous authors, stress the important position of the shrubs as stock feed, and indicate some directions in which more and better use might be made of the Patagonian lands.

The following are two areas of central and northern Patagonia described by Davies. It should be noted that they are both situated relatively near the coast, however, in localities probably less arid than further inland.

(a) A sheep station in the vicinity of the coast, southern Santa Cruz, having an average annual rainfall of 11.1 in. (279.4 mm.). The station occupies 350,000 acres (141,000 hectares) consisting of 50 per cent pampa or undulating grass steppe with patches of shrub steppe, 40 per cent flat expanses of lowland containing numerous salt lagoons which dry out in summer, and 10 per cent gully grasslands or narrow valleys having rich, deep alluvial soil, sometimes quite black. In the pampa tussock grasses form a low proportion of the plant cover, but woody and semi-woody plants, many of them edible, are more important features of the vegetation. Scrub three to four feet high forming a shrub steppe occupies the lowlands of the salt lagoons, many of the shrubs being spinous and even prickly, some edible, some distinctly poisonous. The small proportion of valuable, moister valley soils produce good sown stands of *Medicago sativa*, *M. lupulina* and *Lolium perenne* and are capable of development.

Carrying capacity (Corriedales), one sheep to 6 acres (2.43 hectares).

(b) A sheep station of 370,000 acres (150,000 hectares) in a region near the port of Camarones, Chubut Territory; annual rainfall about 12 inches (304.8 mm.). It is only a few miles inland. The dominant vegetation is shrub steppe with a lower proportion of grass than in areas farther south. The proportions of the various components are:

					Percentage area cover
Shrubs (edible and non-edible) ...	...	...	...	...	44
Grasses (including tussocks) ...	...	...	...	...	38
Other species, including herbs ...	...	...	...	...	18
					100
Bare space ...	...	...	...	...	61

The shrubs are usually only about 2 to 3 ft. (61.0 to 91.5 cm.) in height, and some, for example *Lepidophyllum*, have a prostrate habit of growth. The average carrying capacity of land of this nature is one sheep to 6 to 15 acres (2.43 to 6.10 hectares).

Davies compares the proportions of grasses and other components of shrub steppe at four different points in the territories of Santa Cruz and Chubut in the following table (figures in percentage area cover) :

	A	B	C	D
Shrubs (over 6 in. or 15 cm. high)	50	38	34	82
Woody "herbs" (edible, chiefly <i>Lepidophyllum</i> sp.)	36	26	17	—
Grasses (including tussocks)	14	26	49	10
Other species (herbaceous)	Nil	10	—	8
	100	100	100	100
Bare space	64	70	75	63

The value of the shrub vegetation is fully realized. During the winter months the sheep eat the younger shoots of the low bushes as well as pickings of grass growing in their lee. It is customary on some stations to keep the shrubby growth under control by means of flame throwers, which are used to burn off the bushes and thin them out. This has to be done with care, for many of the edible shrubs do not recover after burning. "What is apparently required is a form of singeing, or the burning of all dead leafage without creating enough heat to injure either the rootstock and green herbage or any seeds lying on the surface of the ground". (Davies, 1940.)

GRASSES

Of the grasses, Fiorda notes that *Stipa* species are the most abundant. This grass forms a compact mass of deeply penetrating roots and has firm leaves terminating in hard, thorn-like tips. In sandy localities a low-growing type is found; in more favourable places it attains a height of 50-60 cm. It is very resistant to grazing on account of its deep roots, resistant also to the cold, drought, and violent west winds of the region, and it serves as a cover for more delicate species. While this *Stipa* constitutes the principal forage grass of the tableland pampas, it is largely replaced by better grasses in the river valleys and in regions of heavier rainfall. (Fiorda, 1940.)

In Hitchcock's Synopsis of the South American species of *Stipa* (1925) the following are mentioned as recorded for Patagonia: *S. patagonica*, *S. humilis*, *S. kurtzii*, *S. argentea*, *S. mucronata*, *S. tenuis*, and *S. hirtiflora*.

Parodi records the following grasses as characteristic of the Patagonian steppe: *Festuca gracillima*, *F. ovina*, *Poa alopecurus*, *P. patagonica*, *P. pratensis*, *Elymus* sp., *Agropyron*, *Hordeum* sp., and various species of *Puccinellia* in salt soils. (Parodi, 1945.)

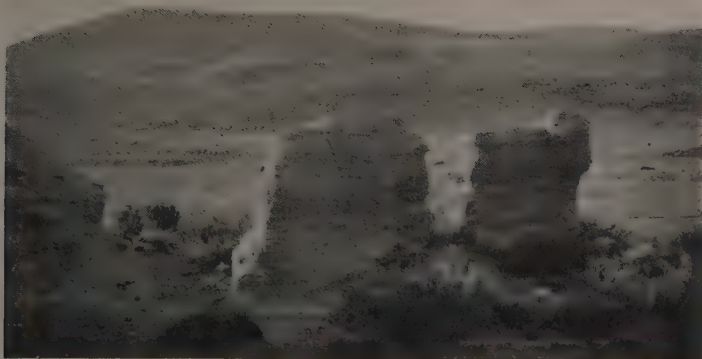
Information on the grasses of Patagonia is also obtainable in the work of Spegazzini (1896-1925) and of Macloskie (1903-1914).

FAUNA

Davies notes that the sheep has many competitors in the numerous wild herbivores that inhabit the great plateaux. He mentions as examples the guanaco (*Lama huanachos*) and the ostrich, and opines that their presence in large numbers probably reduces the actual number of domestic animals that can be effectively maintained.



PL. 5a. ARGENTINA, PATAGONIA. Steppe in the valley of the China Muerta, central Neuquén. (*Photograph by J. FRENGUELLI. 1941*)



PL. 5b. ARGENTINA, PATAGONIA. Steppe north of Las Heras, Santa Cruz. (*Photograph by J. FRENGUELLI. 1941*)



PL. 6a. ARGENTINA. The dry pampa. Hard grasses and *Prosopis caldenia* in the Territory of La Pampa.
(Photograph by J. FRENGUELLI. 1941)



PL. 6b. ARGENTINA. The dry pampa. Transition from grassland to *Prosopis caldenia* "monte" or woodland, Territory of La Pampa.
(Photograph by J. FRENGUELLI. 1941)

Fiorda, on the other hand, deplors the continuous hunting of the guanaco for its pelt, and regards the species as entirely harmless. He draws attention to a serious pest, however, in the hare (*Lepus europaeus*), introduced by an early colonist and now distributed throughout the whole of Patagonia in formidable numbers. The damage caused by the hare lies not only in the herbage it consumes, although this is considerable in amount, but especially in the young trees it destroys, and the growing of trees in Patagonia in any case requires perseverance and care. A more serious pest still is threatened in possible invasion by the common rabbit, which is said to have become liberated in the Rio Verde district of the Chilean province of Magallanes, some 60 kilometres from the Argentine frontier, and—unless early and energetic measures of prevention are taken—may well succeed in penetrating into Patagonia. The smaller native rodents of Patagonia are of no significance as pests, being held in check by the numerous birds of prey inhabiting the region.

EROSION

Fiorda also points out the very present menace of erosion. His theory that an accelerated process of desiccation is taking place has already been mentioned, and he asserts that excessive grazing in many cases is bringing about a denudation of the soil's protective plant cover. The evil is as yet perceptible on a small scale only, but is advancing more rapidly than is generally supposed, and it is believed that unless serious measures of control are taken the results may become disastrous at no very distant date. (Fiorda, 1940.)

IMPROVEMENT

Apart from the river valleys, it is considered improbable that any important agricultural development can take place in the Patagonian tablelands unless expensive irrigation schemes are undertaken. The secret of successful ranch farming on these semi-arid grasslands is said to be : (1) Never overgraze ; (2) Rest completely from stock for one or two years periodically. (Davies, 1940.)

There is much valuable alluvial land in the valleys, however, capable of development. Lopez, writing on sheep farming in the territory of Chubut, has drawn attention to the desirability of using this for herbage. He notes that the only form of artificial ley is that of lucerne, which is confined to a few parts of the Sarmiento Colony and the river Senguer region where irrigation can be practised. It would be relatively easy to replace much of the natural savannah by productive artificial leys of *Phleum pratense*, *Dactylis glomerata*, *Festuca ovina* and other *Festuca* spp., spp. of *Poa* and *Bromus*, and legumes such as *Trifolium hybridum*, *T. incarnatum*, *T. repens*, *Melilotus* spp. and *Medicago sativa*, whereby more nutritious grazing, available for the whole year, would be ensured. (Lopez, 1939.)

Irrigation schemes already in operation in the valleys of the rivers Chubut, Negro, Senguer and others are encountering difficulty in the presence of various salts in the irrigation waters. The irrigated lands are used for horticultural and agricultural crops, including lucerne, that are on the whole sensitive to excess salts. It has been pointed out that under a system of alternate husbandry, including ordinary grass-clover leys (less sensitive to salts than lucerne), coupled with proper manuring and grassland management, pastures of high quality could be maintained and excessive salinity avoided. The present development of the irrigated regions, however, has been concentrated on crops other than grass. (Davies, 1940.)

TYPE 3. SEMI-ARID GRAZINGS

(b) North-eastern Brazil

CLIMATE

North-eastern Brazil is hot and for the most part semi-arid. The causes of the aridity still continue to be debated. Noronha (1938) says the phenomenon is considered to be explained, up to a certain point, by altitude, the direction and force of the winds, the distribution of rainfall and its quantity, and evaporation. Freise (1938) writes that Indian tradition concerning droughts,

and especially discoveries of the remains of forests, indicate that the region is passing through the last period of a cycle that has involved the first occupation of bare rock by inferior plants, the birth, growth, and subsequent decay of forests, the invasion of caatinga (scrub forest), the starving out of the caatinga, and the final appearance of bare rock.

About 35 per cent of the region lies in the zone of equatorial climate and 65 per cent in the zone of subtropical climate. The average of the recorded temperature maxima is $36^{\circ}\text{C}.$; the average of the minima is $18.6^{\circ}\text{C}.$ The prevailing winds are south-east, east and north-east, with a median velocity of less than 2.5 metres per second. There are two well-defined seasons, the winter or rainy season, and the summer, which is entirely without rainfall. Eight per cent of the region receives not more than 10 inches (254 mm.) of rain annually, about 25 per cent 10 to 25 inches (254 to 635 mm.) and the remaining 60 per cent over 25 inches (635 mm.).

The climatic adversity of the region consists not so much in a deficiency of annual rainfall as in its uneven distribution, in both time and place, to which is added the difficulty of retaining and utilizing the water that actually falls. The result is a liability to periodic droughts and floods, often of a nature that is calamitous. About 90 per cent of the rain falls between December and April or early May. Five to eight per cent of the rain falls at the beginning of the rainy season in October, but during the rest of the season the rain is brought in violent showers of short duration covering a small area only. The whole rainfall of a month may be brought by four or five violent showers, all occurring within a few days of each other. The foregoing describes the none too favourable distribution in so-called good or normal years. In bad years, however, several disastrous departures from the normal may occur. In some localities a whole year may pass with no rain at all; in others there may be rain in December and January, but none after that. In some years, again, there may be no rain from January to the end of March, followed by excessive downpours in April and May. The irregularity is very marked. Domingues (1941*b*) states that up to 39 years of disastrous drought have been recorded, alternating with disastrous floods; but on the other hand 32 years in which no drought has occurred have been recorded. Freise has mapped those parts of the region which show a varying tendency to recurring calamities. (Noronha, 1938. Freise, 1938. James, 1941. Domingues, 1941*b*.) There has been a serious drought in the state of Ceará from 1941 to 1944. (Zuckerman, 1944.)

NATURAL GRAZINGS

No less than eight of the Brazilian States participate in this drought region, namely, Piauí, Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas, Sergipe and part of the north of the State of Bahia (Fig. 14). The area occupied is some 540,000 square kilometres, the population is about 5,600,000. The importance of the region for the present study lies in the fact that it is preponderantly used for raising livestock without forage crops, as is shown in James' map of land use. (James, 1941, p. 418.) Coastal grazings of relatively good quality, used for dairying, exist in the littoral zone of north-eastern Brazil, where there is abundant and regular rain, but they are of very limited extent in relation to the inland grazings that represent the characteristic north-eastern type.

Domingues has described these inland grazings in his outline of the different pastoral regions of Brazil (1941*b*). In general they are flat or virtually so, but at times semi-undulating, now in river valleys (but the rivers dry up in the summer), now on tablelands, plains and sandy lands. They nearly always consist of caatinga, the most characteristic plant community of the region, which comprises spinous woody plants, trees and shrubs, chiefly Mimoseae, with Cactaceae, Bromeliaceae and other xerophilous plants. At times even they are forest tracts. Fodder is provided by grasses and legumes and also by semi-shrubs and arboreal plants of different families. The grazings

are for the most part natural, or unimproved, and are composed of grasses such as *Gymnopogon mollis*, *Aristida adscensionis*, *Digitaria sanguinalis*; Cactaceae such as *Opuntia salmiana* and *Cereus variabilis*, *Agallostachys laciniosus*; plants of which the branches are grazed, namely,

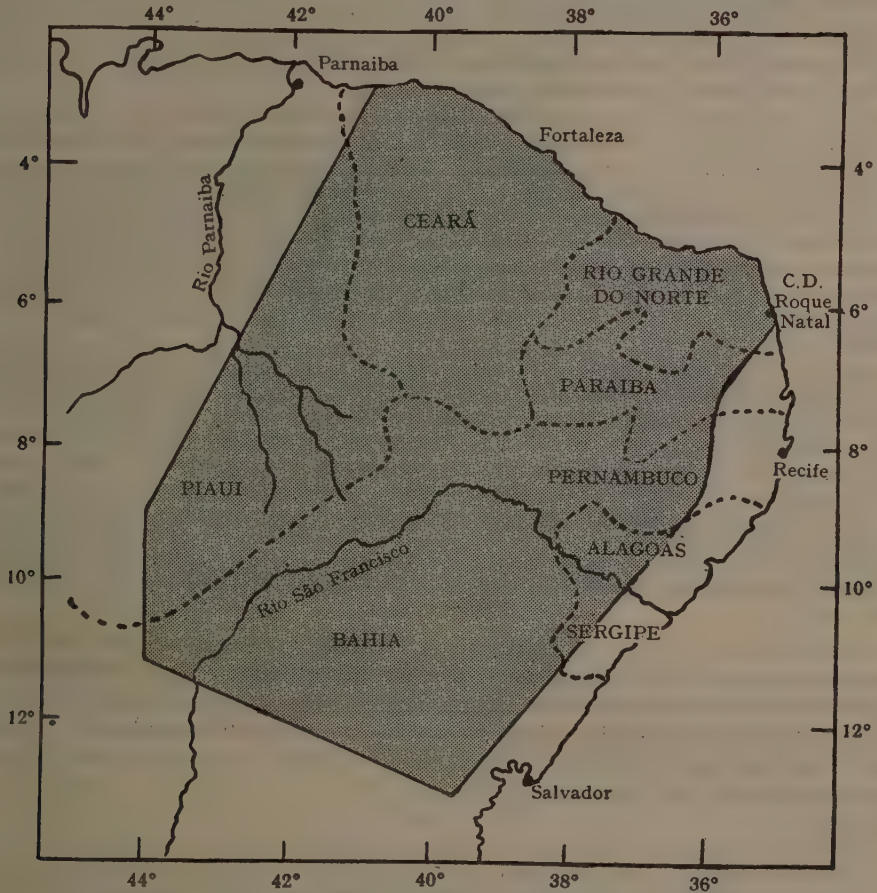


FIG. 14. ARID ZONE OF NORTH-EASTERN BRAZIL

From H. NORONHA. *An. Prim. Reun. Sul-Amer. Bot.*, Vol. 1 1938

Cassia spp., *Piptadenia moniliformis*, *Teramnus uncinatus* (= *Dolichos uncinatus*), *Bauhinia* sp., these last-named all belonging to the family of the Leguminosae. (Domingues, 1941b. *Herbage Abstracts*, 1942.)

GRAZINGS OF CEARÁ

In a book on the animal husbandry of Ceará, one of the States comprising the arid north-east, Domingues says that Ceará is rich in natural herbage and browse fodder in the rainy season. Grasses mentioned are:

Aristida adscensionis, *Gymnopogon mollis*, *Digitaria sanguinalis*, *Paspalum maritimum*; legumes are represented by *Meibomia* spp. such as *M. spiralis* and *M. affinis*, species of *Zornia*, *Centrosema* and *Cassia*,

Stylosanthes guianensis and *Cratylia mollis* ; browse plants are important and include *Cassia multijuga*, *Zizyphus joazeiro*, species of *Bauhinia* and *Ruellia*, *Caesalpinia pyramidalis*, *C. ferrea*, a species of *Pithecolobium*, and *Cordia oncocalyx* ; and the following Cactaceae and Bromeliaceae are resorted to in summer, *Pilocereus setosus*, *Cereus* spp. including *C. jamacaru*, and *Bromelia laciniosa*. Very little is done to cultivate herbage leys, and that on a small scale only, the cultures being confined entirely to grasses such as *Panicum barbinode*, *P. maximum*, *Tricholaena rosea*, *Melinis minutiflora*, *Hyparrhenia rufa*, *Cynodon dactylon*, and an unidentified grass named "canarana." The necessity is urged not only of a wider growing of such grasses—with the aid of increasing facilities for water supplies—but of a simultaneous study of the native forage plants so that the most promising legumes and browse plants in particular may also be cultivated.

The grasses already mentioned, together with several others that have been tested by the Brazilian Experiment Station for Agrostology at Deodoro, are described and discussed at some length, as are also some other plants such as *Atriplex nummularia* and *A. semibaccata*, introduced from South Africa, *Saccharum spontaneum*, and *Manihot* spp. Australian grasses suitable for hot climates, *Astrebla lappacea* and *A. elymoides*, are under trial. The native and foreign legumes that should be studied and, when proved of value, propagated, are also discussed. Contrary to expectations, the spineless cactus (*Opuntia inermis*) has not awakened enthusiasm in north-eastern Brazil. It grows vigorously, but mainly in good and fresh soils which might be devoted to better plants. On the other hand in summer, when it should be of value, it loses its turgidity and becomes coriaceous. The cotton plant is used, grazed by cattle which are turned into the fields after the cotton has been picked. (Domingues, 1941a.)

Of an area 120 by 40 km. situated at an altitude of 700 m. in the State of Paraíba and said to be fairly typical of the north-eastern hinterland, Barros writes that the natural grasslands are composed of *Agrostis montevidensis*, *Panicum verticillatum*, *Aristida setifolia*, and "capim amargoso" [*Andropogon glaziovii*, M. Pio Corrêa, Dicionário, Vol. 1, 1926], and of browse plants such as *Bauhinia forficata*, *Schinus aroeira*, *Lantana* spp., *Ipomoea glabra*, *Cissampelos* sp., etc. In extreme drought recourse is had to succulents such as *Cereus jamacaru*, *Pilocereus setosus*, and a *Melocactus* sp., which cannot be grazed by animals but have to be cut, singed to rid them of spines, and fed to stock. *Encholirion spectabile* is another succulent fed to stock after singeing, and the scarlet flowers of *Neoglaziovia variegata* are eaten by animals, but the leaves of this plant are of no use for forage until the fibre, which is used for textiles, has been removed. Spineless cactus is now being grown to a certain extent, but apart from this cultivated fodders are practically non-existent. (Barros, 1943.)

Concentrates are resorted to in the north-east, especially in the summer, when there is not a green leaf to be seen. With the exception of semi-intensive dairying in the littoral regions, stock raising is of the extensive kind, the animals roaming over the unfenced grazings. All classes of stock are kept, products comprising animals for the meat market (cattle, sheep, goats) ; saddle and draught horses and mules ; cheese for local consumption and export to the south ; hides and fleeces for foreign export. (Domingues, 1941b).

CAATINGAS

A salient character of the caatingas is their loss of leaf during the dry season. The classic description of the caatinga is that given by Martius (1824), quoted by Schimper (1903), and the following citation describes this character : " Dry districts, poor in springs and whose rivers dry up in summer, hills or plains, are the native country of these remarkable forests. The traveller journeys across them only with fear and trembling during the dry months. Surrounding him, as far as he can see, stand the bare leafless stems, motionless, unfanned by the slightest breeze ; not a green leaf, not a juicy fruit, not a verdant blade of grass, on the burning, bare soil ; alone appearing to retain still a fleeting trace of life, are the strangely shapen stems of *Cereus*, which here like huge candelabra, and there crowded together in serried ranks, stand threatening with their poisonous spines. . . . If, however, a sudden shower of rain should loosen the bonds of the vegetable kingdom . . . then, as if by magic, a new world springs into existence. From the richly branched stems, leaves of soft green colour shoot forth, countless rarest forms of flowers expand, the bare limbs of formidable thorny hedges and of climbing plants clothe themselves anew with fresh foliage." (Martius 1824.)

The precarious nature of the subsistence to be obtained by animals from a plant cover of this type needs no emphasis.

Warming (1908, pp. 148-53) describes a similar type of thorn-woodland observed in the more southerly State of Minas Gerais on rocky limestone hills and stresses a disagreeable peculiarity of the caatinga or thorn-woodland, namely, its injuriousness to the clothes and person of the traveller. Herdsmen riding through such country protect themselves from thorns by heavy leather garments. (James, 1941.) A good photograph of a cowboy thus equipped is given by Schmidt in *Bol. Min. Agric. Brazil* 25. No. 10-12. p. 130. 1936.

EFFECTS OF DROUGHT

Years of drought have produced from time to time migrations of the population, an example of which was furnished recently in the departure of some 26,000 workers and their families to the Amazon region from the State of Ceará on account of a drought which set in in 1941 and lasted until 1944. (Zuckerman, 1944.) Exemplary social services were provided by the Government for this army of workers on trek, but "in 1944, the rains came. The drought area took on a greener hue. The Amazon, and its green wealth, seemed less inviting to dried-out farmers looking for lush fields", and it is probable that many of these migrants, like their predecessors, will return again to the north-east. Certainly no permanent effect in reducing the population of the region appears to have been produced by the successive migrations. Domingues, in a book on the animal husbandry of Ceará, writes that the region has bred up inhabitants who—cut off from their fellow men by vast distances and a lack of means of communication, and constantly at grips with difficult and often unpredictable weather conditions—are characterized by independence, courage and resourcefulness. In their unpromising surroundings, harassed by the recurring and prolonged droughts of the region, they have attained a considerable degree of technical skill in the stock raising that is the traditional industry of their habitat, and have often achieved good results.

WATER SUPPLIES

Water supplies, of course, constitute the crux of the north-eastern farmer's difficulties, and Domingues recognizes—as regards efficiency—two types of ranch only, namely, those with and those without water reservoirs. These reservoirs are made by the building of dikes and they have a capacity of 1,000 to 2,000 cub. metres, enough to ensure the growing of green fodder throughout the year, including the dry season. Another form of reservoir seen in the north-east is constructed by excavating deeply into rock or sometimes into soil down to the rock. Water accumulated in the latter type generally becomes covered by a growth of plants which keeps it fresh. Pumps are used in both cases. (Domingues, 1941a.)

GOVERNMENT ACTION

From 1880 to 1889 and again from 1910 onwards steps have been taken by the different Brazilian governments to attack the drought problem. Earlier irrigational work was faultily planned and consequently nullified in due course, but recent irrigational schemes have been based on collected weather records and careful surveys of the natural resources, and already nearly one hundred reservoirs have been constructed. Within the last decade very particular efforts to improve and develop the whole country's agriculture have been made by the Government, from which the north-eastern area also profits. An Institute to co-ordinate and control the work of the various regional experiment stations that are already in existence or to be founded, and similar to the Institute recently established at Belem in the northern State of Pará, is to serve the north-east and will be located probably in the State of Pernambuco.

In the meantime studies are being made at the Government Agricultural Station at Queimadas, in the state of Bahia, where thirty-seven indigenous herbage and forage plants have been tested for their value as hay. Of these sixteen have given successful results, and they are now under examination for their nutritive value. At the same Station trials are being made of *Atriplex nummularia* and *A. semibaccata*, both introduced. It is believed that these salt-bush species could be successfully and usefully acclimatized in the north-east.

In the State of Pernambuco, also, an Experiment Station has been established at Rio Branco for the testing of herbage and forage plants. A herbarium is being formed, and special attention is being given to the subjects of haymaking, the growing of hay plants, and cultural methods in the production of spineless succulents (*Opuntia* spp.). (Farias, 1936.)

MANAGEMENT

Domingues points out that the north-eastern farmer, although he generally possesses a considerable amount of technical skill, works under isolated conditions which make the use of empirical methods almost inevitable. This author stresses the importance of improving the regional standard of agronomy, and considers the introduction of haymaking, in particular, to be a vital necessity. In Ceará, he states, haymaking is practically unknown. The only thing approaching it is the fencing of a certain area of grass which is reserved until the dry season has caused all herbage to disappear from the surrounding prairie. Cattle are then turned into the enclosure, the plant stand of which is referred to as "straw" and, being overripe and very fibrous, is of poor nutritive value and serves as little more than ballast. The author points out that the same enclosures might well be employed as hay fields, when the same grass—cut when it is just beginning to flower—would provide a highly nutritive reserve for the dry season. Ensilage is considered less useful under conditions in Ceará, at all events for the present. In addition, a closer study of the environmental conditions and plant cover, an application of modern scientific methods, and the propagation and possibly the introduction of valuable plant species would result in greatly enhanced productivity. (Domingues, 1941a.)

HERBAGE

The necessity for a study of the native plants is urged by Alencar, with a view to encouraging the growth of those which thrive under the deficient conditions of the region and yet provide nutritious feed. Many of these plants are not actually herbage. Some that are very drought-resistant are said to be toxic but are nevertheless eaten by cattle, which appear to become immune to the poisonous principle concerned: an example of these plants is *Euphorbia phosphorea*. Others, again, give good fodder from time to time but are periodically dangerous, such as the foliage of *Pithecolobium auaremotemo* and a species of *Schinus*, which become toxic on the commencement of the rains; and certain grasses which are rejected when green and excellent when dry. Cactus can be made of use by singeing the spines. Other plants mentioned are *Eupatorium laeve* and the grass *Gymnopogon mollis*.

The Cactaceae are considered to be especially valuable for the region because of their high water content, ranging from 80 to over 90 per cent. Their digestibility also is said to approximate that of maize silage and to be superior to that of *Atriplex*. Suitably mixed with other fodder plants to supply nitrogen, whether grasses, legumes or representatives of other families, the indigenous Cactaceae should assist very materially to solve the north-eastern forage problem. (Alencar, 1941.)

Silva (1936) considers that in the unirrigated drought zone of Pernambuco the fodder shortage might be solved by a systematic utilization of the indigenous forage plants, the Leguminosae in particular. He mentions, with brief notes on their nutritive value and in some cases chemical

analyses, the following : the grasses *Hackelochloa granularis**, *Eleusine indica*, *Agrostis stolonifera* and *Setaria verticillata*†, the legumes *Meibomia spiralis*, *Cassia tora*, *C. ferruginea*, and several browse plants (shrubs or trees, among them some Leguminosae) and succulents.

TREES AND SHRUBS

Souza has recorded that it is an ancient custom in the State of Ceará to use the branches of certain trees in the dry season as feed for stock. The branches are cut early in the morning, because if fed "hot" to stock disturbances of health are produced. In other cases trees are directly browsed by stock. The following are commonly utilized in this way : *Cassia fistula*, *C. ferruginea*, *Caesalpinia bracteosa*, *C. ferrea* var. *cearensis*, *Stryphnodendron obovatum*, *Inga affinis*, *Mimosa verrucosa*, *M. caesalpiniiifolia*, *Bauhinia forficata*, *Erythrina mulungu*, *Bowdichia virgiloides*, *Piptadenia communis*, all belonging to the Leguminosae ; *Soaresia nitida* (Urticaceae) ; *Poraqueiba sericea* (Icacinaceae) ; *Cordia oncocalyx* (Boraginaceae) ; *Zizyphus joazeiro* (Rhamnaceae) ; and *Lecythis pisonis* (Lecythidaceae). All these trees grow naturally and in abundance in various or in all parts of Ceará, and they remain green even under the driest of conditions. Souza urges that not only should they receive protection on account of their value, but that they should be cultivated and propagated. The nutritive value of most of them is good, and *Cordia oncocalyx*, *Mimosa caesalpiniiifolia* and *Zizyphus joazeiro* are said to rival the best forage legumes in nutritive value. In some cases the fruits are also used. *Caesalpinia bracteosa* is especially valuable because it is the first plant to shoot after long periods of drought, and the famishing cattle devour the leaves for about eight to ten days. After this time the foliage becomes hard and of disagreeable taste and smell. When other trees begin to shoot, *C. bracteosa* is abandoned ; as a forage plant it is not of first-rate quality, its value lying mainly in its early recuperation.

Not only does Souza recommend the cultivation of such trees, but he considers that a practice common in Cuba, Japan and Africa should be introduced, namely, the transformation of woody plants into herbaceous plants by means of close planting (50 cm. x 50 cm.) and frequent cutting. It is considered that all the trees recorded for Ceará, and especially the leafy legumes, could be grown as herbaceous plants with great advantage to the animal industry. (Souza, 1943.)

TREES AND SHRUBS AS NATURAL RESERVES

The very great importance in such a region of the fodder shrubs and trees is emphasized by Souza (1943), who paints by no means a black picture of the north-east as stock-raising country. He asserts that the cattle of Ceará keep in good condition, fat, with glossy coats, and free of ticks during the dry summer season (June to November or July to December) in spite of the absence of grass, the dried-up rivers and the almost entire absence of green leaves on the trees, for Nature has provided in this region a type of natural hay. The dried leaves which have fallen from the trees are driven by the wind into depressions such as dry river beds, ditches etc., where they accumulate and form large reserves of fodder to which the cattle resort when every vestige of grass and green leaf has disappeared. If by any chance there should be rainfall in the dry season it would be directly detrimental to stock feeding, for these valuable reserves of dry leaves would become rotten. In this connexion it will be recalled that the value of dried leaves as stock feed has been recognized during the war-conditioned shortage of fodder in Europe, where Liebscher and Demel found that hay prepared from one-year-old shoots of European trees, excepting the oak, can be used in quantities of 1 to 2 kg. to supplement or replace meadow hay without detrimental results, provided care is taken to prevent the development of mould. (Liebscher and Demel, 1943.)

* = *Manisuris polystachya*.

† = *Panicum aparine*.

SEED DISTRIBUTION

In 1942 it was felt by the Ministry of Agriculture that the north-eastern states were insufficiently productive in view of exigencies and restrictions imposed by the world war, and especial efforts were made to encourage and assist agricultural output, particularly by means of distributing large quantities of seed among the farmers. (*Bol. Min. Agric. Brazil*, 1942c.) The north-eastern states will probably constitute the delicate child of the federal Government for many years to come.

TYPE 3. SEMI-ARID GRAZINGS

(c) The western, dry pampa and the monte of Argentina

The customary division of the Argentine pampas, the great plains which lie south of the Chaco and east of the Andean piedmont, into two parts, the humid and the dry pampa respectively, has already been mentioned. James notes that the division is a recent one and a consequence of the introduction of grain farming. To the game-hunting Indian and to the colonial herdsman of rough cattle there was little difference between the tall bunch grasses of the humid pampa and the grassy and tree-scattered bush which lay farther west, for the animals thrived equally well on both. "In fact our concept of the terms 'humid' and 'semiarid' is based fundamentally on the needs of Occidental wheat farming under the economic system of the late nineteenth century". (James, 1941.)

DEFINITION

The western pampa is popularly known as "monte", a Spanish term denoting in South America a xerophilous growth of low, scrubby trees, together with bushes and grasses. The Argentine countryman, writes Frenguelli, calls any land "monte" where wood can be obtained, whether of trees or shrubs, and, by extension, he even names the piece of wood collected "monte". He also uses the term in opposition to "campo" or tract of land covered by herbaceous growth only. (Frenguelli, 1941.)

EXTENT

Its extent is not sharply definable, since the "monte" passes almost imperceptibly into other formations, but if Arena's limitation is taken (Arena, 1938), it is bounded on the north-east by the Chaco, on the east by the humid pampa, on the west by the Andean piedmont, on the north-west by the Puna of Atacama (at an elevation of 2,000 metres), and on the south, approximately, by the Rio Colorado. (See Fig. 8.) The area thus defined includes the greater parts of the provinces of La Pampa, Mendoza, San Luis, Córdoba, San Juan, La Rioja, Catamarca, and the south-western part of Santiago del Estero. The same area is mapped by Castellanos and Pérez-Moreau in their bibliography of Argentine botany (1941), except that they carry it farther south to the mouth of the Chubut river, a southern limit also given by Parodi (1945. See Fig. 6). Frenguelli, however, extends the area of "monte" further north-east through Corrientes and the north of Entre Ríos, completely surrounding the humid pampa like a ring, while he maintains the Rio Colorado southern limit. (Frenguelli, 1941.)

CLIMATE

The climate is described by Frenguelli as "subarid mesothermal, with dry seasons of approximately five months, generally from May to September in the north and centre, and with still less rainfall in the south, but that distributed almost equally throughout the year; with long and hot summers especially in the northern half and with cold winters especially in the southern half:

mean annual temperature from 13° to 20° C. (mean minimum from 5° to 10° C.) ; rainfall from 500 to 900 mm., distributed in 50 to 90 days". (Frenguelli, 1941.)

SOILS

The soils, developed on a somewhat flat relief, range from brown and chestnut to grey. They are nearly always sandy and in many places very saline and even alkaline. (Arena, 1938.) The sandy soil is sometimes superimposed on a substratum also sandy, sometimes on a firm substratum consisting of tosca. (Arena and Guíñazú, 1940.) Monticelli (1938, p. 258), writing of the Territory of La Pampa, gives a schematic illustration of the latter type of sandy soil, showing a granite base below the tosca. The same author records evidence of "a perpetual semi-desert régime throughout the ages" in the poverty of the fossil fauna and in the presence of fossilized sand dunes, now forest-covered. For this Territory, also, he gives the annual rainfall as 400 to 800 mm. and the mean annual temperature as 14° to 23° C. The dry season lasts for five months, and falls between the autumn and the spring. Within recent years the rainfall question has been particularly to the fore, because from 1929 onwards the region has been suffering from the effects of an intense drought said to be unprecedented in modern times. For a period of nine years (1929-37), only in the year 1934 was there rainfall of which the annual total exceeded the average by a small proportion. (Arena and Guíñazú, 1940.) The general tendency of rainfall in the region is to diminish from east to west, and a line running approximately from north to south separates steppe and woodland. (Monticelli, 1938.)

PHYTOGEOGRAPHY

Lack of means of communication, and until relatively recent times the presence of hostile natives, have made the botanical survey of this vast region extremely difficult, and phytogeographical and floristic studies are in consequence restricted to very limited areas. In 1938, however, a monograph published by Monticelli on the Territory of La Pampa, which may be considered as more or less representative of the whole region, has thrown valuable light upon the plant cover of the western pampa. (Monticelli, 1938.)

The study is prefaced by an account of the geological history and the climate of the Territory. The Territory is politically new : until 1880 it was inhabited by Araucanian Indians, its somewhat arbitrary, geometric frontiers being subsequently established by decree. Only the south has a natural frontier, the river Colorado. The Araucanian place names have been for the most part retained, and an interesting feature of them is that they nearly always have some reference to that element so vital for man in semi-arid lands, water.

The general character of the flora of La Pampa is xerophilous and its components all bear the signs of adaptation to drought, to the permeability of the soil, and to the dust-laden winds to which they are subjected. Of the natural conditions governing this vegetation it is mainly rainfall that produces a zonation of the plant species, approximately from east to west, as follows : grass steppe, xerophilous woodland, scrub woodland, and semi-desert. The woodland and scrub are—with some exceptions known locally as "dirty monte", where the close and thorny nature of the plant growth makes passage difficult—of a relatively open nature, and from time immemorial all the above-named associations have served, in the first place as cover and food for the native guanaco, rhea, and other animals, and from colonial days as grazing and breeding grounds for the introduced cattle, horses and mules.

The first zone, the grass steppe, is a continuation of the humid pampa. It is a transition zone abutting on a xerophilous region, and suffers from oscillating conditions, years with abundant rainfall alternating with years of extreme drought.

The xerophilous woodland is first encountered further west, a few leagues before reaching Santa Rosa, the capital of the Territory. The most easterly example covers some 300 hectares and is formed almost exclusively of *Prosopis caldenia*; the average distance between the trees is approximately 20 metres, the trees themselves all being of notable size and thickness. The Telén woodlands, apparently interminable in every direction, occupy undulating ground composed of fossilized sand dunes. Apart from the xerophilous character of its components, this association is of almost tropical luxuriance. Occasionally, but relatively rarely, there is found a strip clear of trees, running in general from east to west and perhaps attributable to edaphic conditions. The *Prosopis* woods are apparently localized usually on the slopes. The dominant species, which easily reach five metres in height, are *Prosopis caldenia* and *P. alba*, in addition to *Gourliea decorticans* and a layer of lower species composed of *Iodina rhombifolia*, *Schinus polygamus* and *Atamisquea emarginata*. The undergrowth and grasses include *Prosopis humilis*, *Cassia aphylla*, *Stipa hypogona*, *S. dusenii*, *Melica macra*, *Trichloris mendocine*, and some creeping plants and epiphytes. There is an average of 10 to 15 metres' space between the trees. The association is described as a natural park, light, and affording ample passage even for vehicles. Its extremely high degree of vitality is based on its resistance to drought and its capacity of recovery from the unfortunately frequent forest fires. In spite of a very great amount of deforestation during the world war of 1914-18 and a permanent lack of forest laws, the area is still enormous, but the devastating practice of "bleeding" these trees for firewood, or making an incision around the base to prevent the ascent of sap (one man can treat as many as 2,000 in a single day), is a very serious menace to the region.

Emerging from the tall tree woodlands towards the west, there is entered the scrub woodland or Fruticetum zone. This form of vegetation is of well-known monotonous aspect, and it is possible for the traveller who enters it without taking the necessary precautions to become lost after a very short time. It is difficult to locate a person and even a motor car in the immense, uniform areas, and the only thing that saves the traveller from panic are the windmills seen every ten or twenty leagues on the horizon, marking the dwelling place of man. This association is obviously less benefited by rainfall but of identical edaphic composition as the tall tree woods, for there is no reason to suspect any discontinuity in the soil. The genera *Larrea* and *Chiquiraga* are apparently dominant in this zone, which extends from north to south, passing through the provinces of San Luis, Mendoza, San Juan, La Rioja, Catamarca and a part of Tucumán and Salta. This is the typical western "monte" formation, with an average of 200 to 300 mm. annual rainfall. It is much less open than the *Prosopis caldenia* association, the average distance between the components being about three metres, but the ground is not covered with lower species as in the tree woods, the sandy soil remaining bare. This sand is coarser than that of the two more eastern zones, the forest and steppe, and it appears as if the smaller the particles, the farther they are carried by the prevailing westerly winds, so that towards the humid pampa the proportion of clay in these soils increases. The principal plant species recorded are *Larrea divaricata* (in the east), *L. cuneifolia* and *L. nitida* (more to the west), *Chiquiraga erinacea*, *Condalia microphylla*, *Prosopis alba* form. *fruticosa* (*P. striata* is sporadic only, in the east), *Schinus polygamus*, *Cassia aphylla*, and rare grasses.

The fourth zone, or semi-desert, is found still further west. The plant cover consists of isolated tufts of low, woody, creeping plants, xerophilous and often fragrant, alternating in the depressions with a halophytic flora that is often luxuriant. Species mentioned include *Lippia trifida*, *Neosparton aphyllum*, *Verbena connotibracteata* in its three forms, *Ephedra ochreatea*, *Grindelia chiloensis*, *Adesmia trijuga* (Andean piedmont element), *Chiquiraga hystrix*, *Senecio mendocinus*, *Atriplex* species, different species of Cactaceae, and some species from the "monte", reduced in size. This flora is continuously invaded by halophytic flora indicating the concentration

of salts in depressions and comprising species such as *Scirpus maritimus*, *Cyperus monandrus*, *Juncus acutus*, *Distichlis spicata*, *D. scoparia*, etc.

The sand dunes found throughout the Territory have a flora of their own which includes the grasses *Panicum urvilleanum* and *Sporobolus rigens* and also (with somewhat less fidelity) *Andropogon saccharoides* and *A. consanguineus*. Sand dunes are accumulators of water, and a special flora invariably creeps up their sides, tending to fix them, if given time by the wind. It is possible for man to hasten this operation, but only where the rainfall co-operates with him: one period of prolonged drought is sufficient to destroy the most careful calculations, and this is more likely the further west the area.

There is in addition a petrophilous flora found in the hills of Lihuel-Calel, which do not exceed an altitude of 500 metres.

FLORISTIC COMPOSITION

Of the 311 species from 65 families collected by Monticelli in the Territory of La Pampa, 57 belong to the family of the Compositae, 38 to the Gramineae, and 22 to the Leguminosae. There follow then the Solanaceae, Chenopodiaceae and the Verbenaceae (21, 17, and 16 species respectively), but the remaining families have few representatives.

The grasses recorded are *Andropogon consanguineus*, the leaves of which turn red in the autumn; *A. saccharoides*, decorative in January and February on account of its white panicle; *Elyonurus candidus*, which covers vast areas of the plains; *Echinochloa crus-galli*; *Digitaria sanguinalis*; *Trichachne insularis*; *Panicum miliaceum*; *P. urvilleanum*, a sand-binding grass having rhizomes capable of penetrating potatoes from side to side; *Setaria mendocina*; *S. globulifera*; *S. argentina*; *Cenchrus pauciflorus*, good forage before it fruits but dangerous to animals afterwards on account of its sharp spines; *Aristida adscensionis*; *A. mendocina*; *Stipa tenuissima*; *S. ichu*; *Muehlenbergia gracillima*, which has deep, aromatic roots; *M. asperifolia*; *Sporobolus rigens*; *S. subinclusus*; *Polypogon elongatus*; *P. monspeliensis*; *Cynodon dactylon*, an invader but not bad forage; *Chloris ciliata*, a halophyte; *Trichloris mendocina*, a decorative component of the *Prosopis caldenia* woods; *Eleusine tristachya*; *Poa ligularis*; *Melica macra*, which has sharp, cutting leaves; *M. argyrea*; *Coriaderia dioica*, a sharp-edged grass of great height, the large white panicle of which is visible from afar, indicating the presence of shallow waters; *Distichlis spicata*, found on the margin of salt lands; *Eragrostis megastachya*, common in the vicinity of dwellings; *Atropis osteniana*, a halophyte; *Hordeum murinum* subsp. *leporinum*; *H. stenostachys*; *Aristida pallens*; *Stipa hypogona*; *Briza triloba*; *Diplachne uninervia*.

Of the Leguminosae recorded, several constitute the large trees of the regional forests, but the following shrub and herbaceous species are of interest: *Cassia aphylla*, ubiquitous in the scrub and also in the forest, a low-growing, leafless shrub of a yellowish green colour, having bright yellow flowers and thin pods grouped in threes, 0.3 to 10 cm. in length; *Melilotus alba*, which attains 1 metre in height; *Glycyrrhiza astragalina*, which has leaves of a beautiful green colour suggesting excellent forage, but is untouched by animals; *Astragalus bergii*, which has toxic pods, lethal to animals and the cause sometimes of serious losses, although after the pods have ripened the plant becomes innocuous; *A. atueli*, also often the cause of death to animals, which eat it with avidity; *Adesmia trijuga*; *Lathyrus nervosus*; *Rhynchosia senna*, ubiquitous from Mexico to Buenos Aires and growing in the driest of soils; *R. corylifolia*, trifoliolate like *R. senna*, but having leaves much larger and unequal; *Prosopis strobilifera*, 30 to 50 cm. in height, semi-climbing, characteristic of humid, salt soils, distinguished by white spines; *P. humilis*, a low, leafless shrub, intensely green in colour and having beautiful flowers with red spikes and strong, red, curved pods, widely disseminated in woodland undergrowth; *P. striata*, a shrub almost without leaves, reaching a height of up to 2 metres, one of the essential elements of the scrub association of La Pampa. (Monticelli, 1938.)

The foregoing description by Monticelli is concerned with the "monte" of La Pampa. Descriptions are also given in a recent publication by Frenguelli (1941), treating successively the "monte" which is called the Selva de Montiel of Entre Ríos and Corrientes, already discussed here under Type 1 (d) (see p. 56); the "monte" of Córdoba and Santa Fé; that of La Pampa and south-western Buenos Aires; and the *Celtis spinosa* woodlands of Buenos Aires. (Pls. 6a and 6b.)

The western pampa, as is seen, consists to a very important extent of monte, which is described by Frenguelli as forming an annular zone, now wide, now very narrow, around the

herbaceous pampa. It may be compared with the scrubs of Australia and in parts with the "chaparral" of Mexico, but its closest analogy is found in those xerothermic associations which, especially in the Sahelian zone of West Africa, have been individualized by the French geographers as "peristeppe woodland". (Frenguelli, 1941.)

USES

Its natural and primitive use as grazing land has been mentioned. In early colonial days the grassy plains between Córdoba, Rosario and Santa Fé were the breeding grounds for the mules which were the only means of transporting goods across the rugged mountain trails of the Andes to the western colonies. (James, 1941.) The Indians, repulsed by the colonists from the eastern plains, retired to the monte with the herds of cattle and horses collected from the colonists and subsequently bred by themselves. At the present time the north-west of the Territory of La Pampa, the south of Córdoba, the south of San Luis and the south of Santa Fé are noted for good grasslands to which store cattle, reared in less favourable regions, are taken to be wintered and fattened. (Tagle, 1942.) The region is also used for agriculture, however. Arena (1938) distinguishes the "irrigated and non-irrigated regions. In the irrigated regions of Mendoza and San Juan, which constitute veritable oases in the immense xerophilous woodlands, horticulture is practised. Lucerne is also grown, and to a lesser extent beetroot and brewer's barley. In Córdoba citrus fruits are grown". Monticelli points out, however, that the western pampa has a rainfall system which will always prevent it from being regarded as a reliable zone for agriculture, nor can any change of climate be expected. In his opinion stock raising still comprises the most logical use of the land, and it is for the agronomist to introduce measures of foresight such as ensilage and for the authorities to restrict the number of cattle and sheep grazed per unit area. (Monticelli, 1938.)

EROSION

As is apparent, the sandy, wind-blown soils of the region are erodible. The open, unprotected plains, exposed to the hot, dry winds from the north and the cold, dry winds from the south-west, are particularly susceptible to any disturbance of the natural balance of soil, vegetation and climate. It is very possible that the drought of the last ten years is due to the large-scale destruction of the native woodlands and of the herbaceous cover of the plains. In addition to drought, an intensification of the velocity of the wind has been produced, together with an increased frequency of the cold south-west winds in the middle of summer. The arid climate natural to the western plains has advanced by way of the plains of the middle west, wedgelike, into the south, where the advancing desert threatens to overwhelm one of the best agricultural zones of the country. At all events, wind erosion has already taken a heavy toll of the middle west region of Argentina (Fig. 15). The Argentine Ministry of Agriculture is making vigorous efforts to survey and deal with the menace. Where the native vegetation and natural grassland has been left undisturbed no erosion has been found, but the destruction of forest, the ploughing of grassland, the tillage of arid land and the continuous growing of a single crop, overgrazing, insufficient diversification, and activities which bring about a falling of the water table have resulted in serious erosion. The water-reducing activities are held to include an excessive growing of lucerne and other temporary leys, and excessive pumping of the ground water for watering stock. The water table at Mackenna, Córdoba, is reported to have sunk from 2 metres to 6 or 7 metres below the surface; at General Pico, in the Territory of La Pampa, from 3-5 metres to 8-10 metres deep. (Arena and Guiñazú, 1940.)

The value of the area appears to lie in its vast proportions; soil and climate alike appear to forbid any attempt at intensive use. Figures as to stocking capacity are not to our knowledge available.

TYPE 3. SEMI-ARID GRAZINGS

(d) Central Mexico

CLIMATE

The climate of Mexico, controlled by the temperature of the bordering seas, the prevailing winds (themselves affected by the ocean temperatures) and the mountainous terrain, is in the main arid and semi-arid. Only a small proportion of the country has an average annual rainfall exceeding 40 in. (1,016 mm.), and a very large area has a rainfall of only 10 to 20 in. (254 to 508 mm.). Actual desert conditions extend across northern Mexico as far as the east coast. The arid and semi-arid climate prevails generally in the great central uplands in which about one-half of the population lives, the areas of higher rainfall being situated nearer the coasts. (James, 1941.)

LAND USE

Maps of land use in Mexico (James, 1941, pp. 618 and 640) show that the greater part of the central highlands consists of grazing lands, and these, according to Weaver, are a part of the great mid-continental prairie which continues northwards across the entire United States and up into Canada. "Throughout the entire Prairie Formation the climate is more favourable to grasses than to trees or shrubs or, indeed, to any other type of vegetation. But within the vast range of grassland climate, marked differences exist in degrees of favourableness for growth." (Weaver, 1944.) Weaver discusses these differences as they affect the plant cover of the North American continent, and there is no doubt that the plant cover of the Mexican grazings is similarly affected by the different minor grassland climates, wherein differences in precipitation and relative rates of evaporation are of more importance than differences in temperature and length of growing season. In the United States short grasses are found to occur mostly in areas of low precipitation such as the Desert Plains Grassland of the far Southwest (Weaver, 1944), and Shreve notes in the desert region of Northern Mexico that short grasses form a turf which covers 80 per cent or more of the surface. Cactus-Acacia grassland is also a feature of this region. (Shreve, 1941.)

PHYTOGEOGRAPHY

The Institute of Biology, Mexico City, is devoting much labour to the floristic study of Mexico, and a helpful account of the central highlands, among other parts of the country, was published by its Director, Dr. I. Ochoterena, in 1937.

Ochoterena separates Mexico into a number of geo-botanical divisions including the region of the central plains, which is again divided into two sub-regions, the one temperate and dry, the "plains of the south", and the other a hot region lying south of the central tablelands. It is in the temperate and dry southern region of the central tablelands that the valley or basin of Mexico is situated, together with the valleys of Toluca, Puebla, Morelia, Tlaxcala and others. The plants of this region have to adapt themselves to a dry and burning heat in the summer, to excessive cold during the winter, to a high degree of evaporation, to violent winds, and finally to a deficiency of water. Five natural families in particular contain species able to resist such unfavourable conditions, namely, the Leguminosae, the Gramineae, the Cactaceae, the Compositae and the Liliaceae, and these families—with the exception of the last-named—are abundantly represented in the central region.

FLORA

Of the large and important family of the Gramineae there are numerous representatives in the basin of Mexico. The tribe of the Maydeae is represented principally by the genera *Euchlaena* and *Tripsacum*. *Euchlaena mexicana* or teosinte is found solely among maize plants; *Tripsacum dactyloides* is a beautiful and sturdy grass found especially in stony regions. Among the species of Andropogoneae which inhabit dry localities there

should be cited *Andropogon saccharoides*, with white inflorescences, and *A. glomeratus*, characteristic of the steppes. Representatives of the Zoysiae are the genera *Aegopogon cenchroides*, a soft grass with green or reddish unilateral spikelets; *Hilaria cenchroides*, a low-growing grass with black inflorescences. The tribe of the Paniceae is represented by numerous species: *Cenchrus pauciflorus*, found in sandy lands (at the foot of the Sierra de Guadalupe); *Setaria*, which has only a few species in this region, namely, *S. glauca*; *S. viridis*; *Paspalum distichum*, principally in the moister localities; *Echinochloa crus-galli*, in moist localities; *Panicum*, of very varying appearance with spikelets arranged in spikes or panicles; *P. bulbosum*, with subglobose rhizomes, in the steppe; and *P. dichotomiflorum*, aquatic. The Agrostideae are represented by *Aristida* in dry and sandy localities; *Stipa*, with narrow leaves sometimes curved in and with paniculate ears, in dry places; *Muehlenbergia*, of very varied aspect; *Sporobolus*, with panicles contracted or open, of different aspects, some very frequent; *S. indicus*; *S. plumbeus*, in salt localities; *Polypogon*, erect or spreading, with inflorescences in the shape of narrow panicles; *Epicampes*, robust, rigid, with a long and narrow panicle, found in the high regions of the valley; *Agrostis semiverticillata*, very common in parts. Among the Aveneae there is found *Avena*, with large spikelets in open panicles. The Chlorideae are represented by *Buchloe dactyloides*, a low grass with creeping rhizomes; *Cynodon dactylon*; *Bouteloua*, elegant, annual or perennial. Some examples of the Festuceae are *Diplachne*, which forms large sods; *Eragrostis*, tall, with fine panicles, of good appearance; *Distichlis*, with creeping rhizomes, rigid and piercing leaves and paniculate spikelets; *D. prostrata* and *D. spicata*, very important for fixing the shifting sands around Texcoco; *Poa*, found in the temperate zones; *Festuca amplissima*, in the mountain region.

Cultivated grasses are *Triticum vulgare* (wheat), *Secale cereale* (rye), *Lolium multiflorum*, cultivated in parks and meadows; *Hordeum vulgare* (barley); *Phalaris canariensis*, cultivated and acclimatized in the central valley; *Arundo donax*; *Dactylis glomerata*, imported from Europe as good fodder. The Cyperaceae are abundant in moister or marshy localities; *Cyperus bourgaei*, a tall species; *C. seslerioides*, found in the stony regions; *Mariscus pycnostachyus*, abundant on the banks of the rivers.

Of the legumes the following genera are found: *Crotalaria pumila*, which grows in the steppes and stony regions; numerous species of *Lupinus*, the majority of them American; *Melilotus indica*, with yellow flowers; *Trifolium*, very well represented by wild and acclimatized species, *T. amabile*, *T. involucreatum*, and *T. repens* are those called clovers; *Medicago sativa*, the cultivated lucerne; *Indigofera suffruticosa*, important for its industrial use; *Dalea citriodora*, an annual herb with small flowers; *Phaseolus vulgaris*, a generally cultivated plant; *Calliandra grandiflora*, a herb or shrub, which grows in the stony regions and the steppes.

In addition to the grasses and legumes a large number of shrubs and herbaceous plants are present, the Compositae being amply represented. Some typical examples of the last-named family are *Baccharis conferta*, *Vernonia* species and various species of *Eupatorium*, etc. Important components of the plant cover are also various species of the Cactaceae such as *Opuntia tomentosa* and other *Opuntia* spp. Numerous species of the genus *Agave* and *Fourcroya* are also characteristic. Shrub-like legumes are *Spartium junceum*, a shrub almost deficient in leaves, with large yellow flowers; *Mimosa biuncifera*, a thorny shrub with rigid branches; and *Caesalpinia cacalaco*, a low and spinous tree with large flowers and pods rich in tannin. Trees are also interspersed among the plant cover, isolated or in groups; among them are found *Yucca* species, and various species of *Acacia* and *Prosopis*. (Ochoterena, 1937.)

As in other arid and semi-arid lands, shrubs and trees are of great seasonal importance for the feeding of animals. It is reported that during the dry season some cattle get their entire nourishment from mesquite (*Prosopis juliflora*) and similar plants. (Johnson, 1944.)

CROPS v. STOCK

Although the central area of upland prairie (together with scrub such as forms the basis of successful stock raising in other countries) comprises so large a proportion of the land of Mexico, and although, as has been noted already, the greater part of this enormous area is registered as used for grazing without forage crops, the animal industry of the country has not become intensified or developed to any noteworthy extent. The early Spanish colonists found highly civilized Indian peoples already in occupation, for the most part sedentary communities practising crop growing with a high degree of efficiency. It is true that, as elsewhere in Latin America, the European colonists introduced live stock, the requirements of which were completely met by the abundance of natural grassland found in every climatic zone, but in Mexico the Indian form of agriculture, the

agriculture of the crop grower, has remained dominant, the pastoral activities of the colonists never attaining more than a secondary position. There is a marked contrast here with what has happened in Argentina, Uruguay and—although not quite so markedly—in Brazil, where the stock raising of the colonists was readily adopted by the nomadic Indians of those countries and where (at all events in Argentina and Uruguay) the animal industry has become the backbone of the national agricultural economy. Certain social and economic causes appear to account for the undeveloped pastoral industry of Mexico, the principal reason being the lack of home demand for fresh meat and dairy products. The per capita average annual consumption of meat is 40 pounds only, as compared with 156 pounds in the United States and 290 pounds in Argentina. (Simpson, 1937, quoted by James, 1941.) The staple food of the Mexicans to-day is still that of the Indian populations who preceded them, namely, maize.

A considerable amount of land is thus necessarily devoted to the growing of maize, a soil-depleting crop, and it is a moot point whether the use of much of this land for maize is not a danger to the natural resources of Mexico. At all events, the problem of erosion is stated to be one of the most serious with which the Mexican Government has to deal at the present time (Patiño, 1940).

THE BASIN OF MEXICO

In this connexion attention is drawn to an interesting suggestion of James (1941), speaking with special reference to the central region or core of Mexico, which includes 14 per cent of the area of Mexico, 15 per cent of all the agricultural land, 45 per cent of all the farmers of the country, and more than 50 per cent of all the area devoted to maize. The land is composed of a number of well-defined basins, including the Basin of Mexico in which the capital city is located. In the Basin of Mexico maize, grown on hill slopes, is by far the most important crop in terms of area. All through the central region large areas are devoted also to the cultivation of *maguey*, a species of *Agave* from which a popular alcoholic drink is made. James considers that the Basin of Mexico has undeveloped possibilities, and that it could provide excellent conditions for the grazing of cattle.

The Basin of Mexico is a depression of irregular shape, some thirty miles (48.3 km.) east and west by fifty miles (80.5 km.) north and south. The total area, according to Bukasov (who describes it under the name "Valle de Mexico") is 13,500 square kilometres, the altitude 2,300 metres (Bukasov, 1930). The bottom of the basin was occupied by five lakes in the time of the Aztec civilization, and agriculture took place, as it still does, along the margins of the lakes and on the lower and gentler slopes of the surrounding mountains, but the lakes have since been drained (there is no natural drainage to the sea). The presence of salts in the lake-bed soils has precluded their use as arable land, and even in the better marginal lands productivity has declined. James considers that the physical conditions would favour an intensive pastoral economy: "the grasses are nourishing and remain green and edible throughout the year; the temperatures are low enough to reduce insect pests to a minimum, and dairy products could be handled without the usual difficulties encountered in tropical countries". Elsewhere, speaking of the central area generally, he notes that although most of the maize consumed in Mexico is grown in this area because about one-half of the population is concentrated in it, the average yield per unit area is extremely small, namely, 8.7 bushels per acre compared with 31 bushels in Egypt, 27 bushels in Argentina, and 21 bushels in Italy. The central area, he considers, could be put to much better use than the growing of maize, for which it is clearly unsuitable. The relative freedom from pests, the abundance of surface water, and the nourishing quality of the grasses "all point to this as a natural cattle-producing region", and it is believed that the present stocking of cattle could be doubled. (James, 1941, pp. 655 and 662.) Here it should be noted that the largest concentration of cattle is already

to be found in the vicinity of Mexico City, although there are more cattle per capita and larger individual herds in the northern part of Mexico. (Johnson, 1944.)

The natural floristic composition, as described by Ochoterena, has already been noted. In considering the value of the region for a more intensified cattle industry, however, the semi-arid nature of the general climate must naturally be taken into account, together with the regional climatic differences to which Weaver has drawn attention. The pastures of Mexico vary from luxuriant cultivated grasses to more or less woody types of vegetation, but range lands form the most common types of grazing, and it is probable that the improvement of some of these could be effected.

PRESENT TRENDS

A recent article has reported that the cattle industry in Mexico is now definitely on the upward trend. Prices are at a high level, the demand has become brisker, and more profitable workings have enabled many graziers to make the improvements generally agreed to be necessary, namely, more fencing and the provision of water facilities. The present carrying capacity of much of the land in the central and northern parts of the country is one head of cattle per 10 acres (4.05 ha.) or more. (Johnson, 1944.) Similar figures for carrying capacity are given by Smith, who says: "The usual carrying capacity of much of the pasture land in the central and northern parts of the country is 1 animal to 10 or 18 acres (4.05 or 7.3 ha.). Some land, however, will carry only 1 head to 25 or 30 acres (10.1 or 12.1 ha.). Some of the best land in the Huasteca area carries 1 animal to 1.5 acres (.607 ha.)." (Smith, 1944.)

TYPE 3. SEMI-ARID GRAZINGS

(e) The campos of central Brazil, a transitional type

THE FORMATION

There are very large areas in Brazil known as "campos", which occupy an intermediate position between the arid and semi-arid grasslands just considered and the better types of grassland described under Type 1. The campos are composed of savannah of two kinds, the treeless savannah known as "campo limpo" and the savannah with scattered trees known as "campo cerrado". While this is no uniform formation, but one in which different forms of woodland and grassland partake, the latter preponderates (Schimper, 1903), and from the earliest days of European colonization the campos have been used for stock raising. The formation covers enormous areas of elevated plain, often undulating, in the central, eastern and southern states, and Domingues in his grouping of Brazil's grasslands has distinguished two regions of intermediate, campo grasslands, the northern central and the southern central, leaving out of consideration the campos of Rio Grande do Sul and the other states situated south of São Paulo, which have been discussed elsewhere. Seasonal aridity is a disadvantage of these lands, for the winter is without rainfall. The summer, on the other hand, is rainy and hot, and the season in which stock-raising conditions are best.

BOTANICAL COMPOSITION

The natural pastures have been improved in some parts by planting *Melinis minutiflora* and *Hypparrhenia rufa*, with a small proportion of *Panicum maximum* and other grasses. (Domingues, 1941b.) Describing the campos of São Paulo, in which State they appear to be most successfully utilized for the cattle industry, Corrêa notes the above-named grasses together with *P. maximum* var. *gongylodes*, *Chloris gayana* and *Pennisetum clandestinum*, which furnish satisfying and wholesome fodder for much of the year, but need to be supplemented in winter and in any other

dry spells by additional rations. (Corrêa, 1936.) *Melinis minutiflora* pastures are formed from seed and make a large amount of top growth, but, unless carefully stocked, they tend to thin out in a few years and become badly overgrown with weeds or scrub. *Hypparrhenia rufa* grazings are, perhaps, the most valuable from the stockman's point of view and can be compared in appearance, when systematically stocked, to an English pasture. If allowed to create too much growth the grass becomes tough and unpalatable and forms tall clumps and tussocks. *Panicum maximum* is a grass fairly new to the State of São Paulo, but is attaining some measure of popularity. It forms a pasture that requires careful stocking, otherwise it produces clumps of top growth with stems as tough as thin bamboo. (Pheysey 1947.)

USE

Kok, writing of the same State, says that in some respects it has certain advantages, for example, in the cold season there is never an absolute lack of feed and in the dry season conditions are seldom so bad that the herbage is actually destroyed, although it deteriorates in quality. The chief disadvantages encountered by the grazier are a deficiency at all times of protein and mineral elements, especially phosphorus and calcium, which is in direct relation to the poverty of the herbage in legumes; and the already mentioned shortage of fodder in the dry season. (Kok, 1943.) These disadvantages are reflected in the type of cattle raised, in general poorer than that, for example, of the State of Rio Grande do Sul. In many parts the poor quality natural herbage has already been superseded by leys sown down on land reclaimed from forest. (Corrêa, 1936.) Pastures are usually far too large, so that stock wander over much more than they need and grazing is very selective. Rearing is more commonly done in the States of Goyaz or Minas Gerais, and at one or two years old the young stock are trooped into pastures of São Paulo for fattening. (Pheysey, 1947.)

IMPROVEMENT

Kok suggests in addition the growing of crops such as mandioca (*Manihot aipi*) and sugar cane (*Saccharum officinarum*); haymaking, an uncommon practice in the region, *Hypparrhenia rufa* and *Chloris gayana* being mentioned as suitable for the purpose; and ensilage, notably of maize, the cost of which should not be prohibitive. To meet the deficiency of legumes characteristic of most of the natural and artificial grasslands of the State, it is suggested that instead of growing lucerne—which is not economic in some parts of the region—it would probably be better to disseminate certain indigenous and introduced legumes which have recently been the subject of study. Results obtained up to the present indicate the probable usefulness of *Arachis prostrata*, which has been very valuable in some other Brazilian pastures, *Indigofera* species and *Meibomia barbata*, all the foregoing for pastures. For hay and soilage an indigenous plant, *Meibomia discolor*, is said to be of special interest, and for field crops cowpeas (*Vigna sinensis*), kudzu (*Pueraria thunbergiana*) and *Mucuna* are considered likely to be of great importance for the future feeding of dairy cattle in São Paulo. (Kok, 1943.)

DEVELOPMENT

In recent years there has been an increasing diversification of agriculture in the State of São Paulo, old coffee plantations having been replaced by good quality pastures in some parts; and an expansion of the cattle industry has taken place, especially in western São Paulo. (Keeler and Lankenau, 1941.) Dr. Fernando Costa, formerly Minister of Agriculture for Brazil, when touring the State in 1943 noted that 50 per cent of its land is suitable for animal husbandry. "We have great facilities for the rearing of every type of useful animal, from the bee to the bull." At the same time he stressed the fact that the herbage of the São Paulo grazings was unable to

compare in quality with that of some foreign and notably of European countries, and considered that in the breeding of live stock care should be taken to maintain the necessary hardiness characteristic of the indigenous breeds. Breeding stock should not be permanently stabled or fed on special fodder. Under São Paulo conditions, animals must be capable of travelling long distances, of tolerating the hot summer sun and of thriving on the somewhat poor herbage. (Costa, 1943.)

ECOLOGICAL CONDITIONS

Of considerable interest in regard to the Brazilian campos are ecological studies of the plant cover of southern Brazil now being made by Rawitscher and collaborators at the University of São Paulo. A study of typical "campos cerrados", or savannahs interspersed with trees, at Emas, near Pirassununga, showed that they do not present arid conditions such as are usually implied when they are included among the savannahs. The water content of the soil is considerable. The underground water table was found at 17 to 18 metres. The vegetation consists of plants which grow only during the rainy season; grasses with superficial roots, which wilt when there is a deficiency of moisture; and shrubs and small trees with very deep roots. One species of *Andira* has roots which enter the water table at 19 metres. Studies of the plant stomata showed them to be open throughout the day. The behaviour of the plants is not that of xerophytic vegetation. (Rawitscher, Ferri and Rachid, 1943.) Studies of the soils "as a botanist sees them" show them to be of great depth. The summer rains can be stored in great quantities, and studies of some of the regions considered to be among the driest in the country showed that the vegetation, generally called xerophytic, does not lack water even in the climax of the dry season provided the roots can pass through the first two or three metres of the soil, the only ones affected by the drought. The existence of so much water accessible to plants in the deep layers of apparently arid lands proves that the present plant cover does not correspond to the natural conditions and does not represent the regional climax.

BURNING

"The scarcity of the vegetation does not result from scarcity of water, but is a consequence of the annual burning off of these lands. What should be the real climax of the vegetation cannot yet be predicted, in view of the lack of data and observations on the subject." (Rawitscher, 1944.) Ferri, in a study of the transpiration of plants of this region, which show no feature of xerophytic behaviour but freely use large quantities of water even during the driest periods, comes to much the same conclusion, although he suggests that if the practice of burning were suppressed, a richer, forest-like vegetation might conceivably ensue. (Ferri, 1944.) Rawitscher considers that a good way of controlling soil deterioration would be the growing of green manure crops, which would not only protect the soils from erosion and leaching, but, if plants with deep rooting systems were chosen, would also return to the surface layers the minerals absorbed from greater depth. (Rawitscher, 1944.)

CHAPTER 6

THE NATURAL GRASSLANDS

TYPE 4. SAVANNAHS OF HOT CLIMATES

(a) The Orinoco flood plains or Llanos of Venezuela and Colombia

(i) The Venezuelan Llanos

The first sight of the great Venezuelan plains, the Llanos, has ever made a stupendous impression upon the mind of the beholder. "I know not," wrote Humboldt, "whether the first aspect of the Llanos excites less astonishment than that of the chain of the Andes." (Humboldt, 1852.) A graphic description has been given recently by Rainier, who first saw the area from the western side at a spot high up in the Colombian Andes. "Looking from the mine through that beetling Guavio Gorge you saw what seemed like an ocean horizon, the horizontal straight line which separated sea from sky. But this ocean was green and through it meandered yellow streaks. An ocean of grass. The Llanos. The vast plains which stretch from the Andes foot to the Orinoco River a thousand miles to the eastward. Those yellow streaks were rivers. Mile-wide yellow rivers. Mighty tributaries of the still mightier Orinoco." (Rainier, 1943.) Another, and one of the earliest descriptions, gives the impressions of explorers landing from the Orinoco river itself in 1521 and pushing northward over the plains. "Crossing the bare silt at the water's edge, they entered the zone of high grass. The horsemen were almost hidden in the sea of vegetation, which presented the greatest obstacles to their advance. It took all the strength of the horses to push a way through the thick growth of interlacing stems, tangled inconceivably, as though this was the first time that the agitations of man had creased a furrow in that millennial calm, under the impassible serenity of those skies." (Albeñiz de la Cerrada, translation, quoted by Myers, 1933.)

Humboldt (1852, quoted by Myers, 1933) also emphasizes the stillness of the Llanos. "Everything seems motionless; scarcely does a small cloud, passing across the zenith, and denoting the approach of the rainy season, cast its shadow on the earth." James (1941) describes the Llanos as "a vast almost featureless plain". The monotony to which many travellers have referred is, however, apparent only, at all events as far as the plant cover is concerned.

PLANT COVER

"Whoever has not had the opportunity of seeing the Llanos of Venezuela with his own eyes and of crossing them in all directions, is apt to imagine them as an immense plain, covered with tall grasses and intersected by majestic rivers having banks fringed by beautiful rain forests. This is the picture we find in much of the literature. But in reality there is no uniformity in the region: its topography is very varied and ranges from altitudes of less than a hundred metres on the one hand to over three hundred on the other; its lands are in part arid and almost sterile, in other parts very rich and fertile; its plant cover changes from place to place: here there are vast savannahs almost bare of trees, there more or less dense rain forest or groups of trees which arise in the midst of great meadow lands; again there is fringe forest, now veritable forest with the most varied vegetation, now reduced to narrow strips of palm grove (*Mauritia* sp.). The aspect of the Llanos varies also with the season; in summer hundreds of kilometres of savannah may be crossed without difficulty, but the same area in winter may be obstructed by water channels, lakes or impenetrable marshes." (Pittier, 1942.)

In another place the same author writes : " The Llanos are not a vast plain covered with green meadows, as various authors have described it, but should be regarded as a complex of plant formations distributed over a more or less dissected area. There are spaces, sometimes of considerable size, that are entirely without trees ; in other parts the combination of clumps of trees and of savannah gives rise to park landscapes ; and finally, the numerous rivers which intersect this wide territory are fringed on both sides by a strip of woodland, more or less broad in accordance with the degree of permeability of the soil." (Pittier, 1939, p. 14.)

SITUATION AND CLIMATE

The Llanos lie to the north of the 1,600-mile-long (2,580 km.) Orinoco River and occupy an area approximately 600 miles (966 km.) long and 200 miles (322 km.) wide, forming roughly a semi-circle from the river Guaviare in Colombia, a tributary of the Orinoco, approximately 4° S., to the Atlantic coast of Venezuela. They slope very gradually from the base of the Andes towards the river, but seldom exceed an altitude of 600 or 700 feet (183 or 214 m.) above sea level even at their highest part. (James, 1941. Coiner, 1945.)

The whole of the Llanos are thus contained within the so-called " hot lands ", the altitude range of which in Venezuela is 0 to 1,000 metres, the temperature range 28° to 20° C. Variation in temperature during the course of the year is far from being uniform everywhere, however, even at equal altitudes. The temperature curve at Ciudad Bolívar, a city in the eastern part of the Llanos and their commercial centre, follows an almost parallel course with that of Port-of-Spain, Trinidad, with minima in January and July and maxima in May and October. At Calabozo in the central Llanos, 9° N. and 67-35° W., the greatest monthly variations recorded in Venezuela are found, with a principal maximum in April and a principal minimum in July, and a secondary maximum and minimum in December and January respectively. Differences of this nature are bound to have some effect on the plant cover. (Pittier, 1939.)

Of great importance for the climate of the Llanos are the winds, which act as moderators of the excessive heat and at the same time exercise a considerable influence on the distribution of the rains. Venezuela is entirely under the régime of the eastern trade winds, the direction of which varies during the course of the year, following the sun to the north or to the south of the Equator. When the mountains are in a transverse direction to that of the wind the latter rises and condensation is produced in the form of clouds. In addition to these winds, local breezes, such as alternately ascend and descend valleys during the day and the night, also exercise a certain influence on the climate and, indirectly, on the distribution of plants. (Pittier, 1939.) The warm, moisture-gathering trade winds also have an effect in drying the great plains after the rainy season. (Jones and Darkenwald, 1941.)

The Llanos are commonly referred to as " windswept ", and it has been observed that in many parts the soil is very badly wind-eroded, the fine top soil having been removed in places, exposing the gravel. (*Chron. bot.* 1941.)

The mean annual rainfall fluctuates from 800 to 1,800 mm. and the days of rainfall from 75 to 150. There are two seasons, the rainy season, which begins in April but reaches a maximum in June or July, continuing then until October and with occasional showers into November to December, and the dry season, January to March, during which there is no sign of rain. The curve for the mean annual rainfall is very regular in the Llanos. (Pittier, 1939. James, 1941.) Exact rainfall records, however, appear to be lacking. (Myers, 1933.) The rainy season is always accompanied by the inundation of vast tracts of land, especially in the vicinity of the Orinoco.

THE FORMATION

In Beard's study of climax vegetation in tropical America six formation-series are recognized. Savannah forms one of the marsh or seasonal swamp formations. The essential basis of these formations is soil that is seasonally waterlogged or inundated and seasonally desiccated. (The term "marsh" is distinguished from "swamp", which while seasonally inundated is never completely dried out.) "Since there is no downward percolation of rain water, the soil waterlogs in the rainy season. In the dry season the shallow upper layer to which roots are confined dries out completely and quickly." (Beard, 1944.)

Myers, who summarizes the views of previous authors on the ecology of the Llanos, himself regards them as true climatic grasslands, and recalls that Schimper (1903) describes the climate as one hostile to woodland on account of the rainless season of five months, during the greater part of which the dry easterly trade wind blows almost continuously. (Myers, 1933.) This view was previously expressed also by Pittier (1926) in an interesting description of the perpetual battle waged between the two great formations, woodlands and grasslands, into which the plant cover of Venezuela is divided. He concludes that however accidental circumstances such as firing, grazing by cattle, etc., may affect the course of the struggle in one direction or another, the present equilibrium between grasslands and woodlands would be maintained by the climate.

Beard notes that while primarily a grassland, savannah may take the form of pure grass (open savannah), grassland with scattered gnarled bushes (orchard savannah), with pine (pine savannah) or with occasional fan-palms (palm savannah). (Beard, 1944.) According to Pittier, all these types except the pine savannah are represented in the Llanos, but the information on their floristic composition is as yet scanty except in the case of the coastal stands of tall bunch grasses, which have been fairly well explored. (Pittier, 1926.)

FLORISTIC COMPOSITION

Nevertheless some rather scattered information is available. Pittier (1926) lists as the dominant families represented in the central Llanos not far from Caracas the following, in order of importance: Gramineae with *Paspalum* (9 species), *Andropogon* (9 species), *Panicum* (6 species), *Eragrostis* and *Sporobolus* (4 species each) as the principal genera; Leguminosae with *Meibomia* (11 species), *Cassia* (9 species), *Mimosa* and *Aeschynomene* (4 species each), etc.; Compositae; and Cyperaceae. The forest element is represented by species of *Roupala* and *Byrsonima* (see Pl. 9b), and some species of the Myrtaceae.

He has also given an account of the trees and shrubs most frequently found in the fringe woodlands of the rivers, the clumps of trees and the palm groves of the Llanos. While space forbids their full enumeration here, there may be noted the presence in dry thorn woodlands of Leguminosae such as *Mimosa cabrera*, *Caesalpinia coriaria*, *Pithecolobium tortum*, *P. guaricense* and others, and—within perfectly defined limits and never together—of palms such as *Copernicia tectorum*, *Bactris* spp., *Attalea* and *Oenocarpus* in the higher Llanos, and a species of *Mauritia* in the lower Llanos. This last-named palm, formerly identified as *M. flexuosa* but now as *M. minor* (Pittier, 1942), is an indicator of conditions nearly always perilous to the traveller, for it grows in dense clusters together with evergreen plants in swampy, very slowly drained lands. (Pl. 9b.)

The distribution of the different types of woodland, or their absence, are illustrative of the different types of land that make up the Llanos. The land is entirely of alluvial formation; the soils vary from gravels to silts approximately from north to south, with a total absence of stones in the lower Llanos. (Myers, 1933.) River erosion has formed a series of so-called mesas or tablelands, scattered throughout the whole of the Llanos; their soil is arid and sandy, and they are covered by sparse, continuously windswept vegetation. The lower Llanos are of more permeable

soil, and here the swampy lands are found. Thorn woodlands fringe the upper Llanos. (Pittier, 1926.)

The grasses of the savannahs vary in size from a mere carpet to a thicket the height of a man on horseback. (Pittier, 1926.) Myers, who toured a section of the Llanos in the dry season, records that between the northern coastal range and the Apure river they consist for the most part of bunch grass savannah as the term is used by Bews (1929), of a type intermediate between the tall and low classes but tending largely towards the latter, while to a varying distance from the rivers Apure and Portuguesa there is a wide zone of high grass savannah with an overwhelming dominance of *Paspalum fasciculatum*. (Myers, 1933.) Chase also records that the marshes along the river Apure are "practically pure stands of *Paspalum fasciculatum*, its creeping interlacing stems making a firm network holding the alluvium and its erect stems forming a dense growth 3 to 7 feet tall". Many smaller areas of this grass are found in the Orinoco valley and extensive zones in the Delta above tidewater. (Chase, 1944.) Myers notes as the dominant grasses of the northern bunch grass savannah the species *Cymbopogon rufus* over very large areas, and, over smaller but still extensive areas, *Andropogon condensatus* and *Sporobolus indicus* respectively. In the great stands of the coarse *Paspalum fasciculatum* he found at times, but rarely, flowering stems of the more slender *Eriochloa punctata*, and, especially on the flatter beaches, a few other grasses including *Panicum elephantipes*, *Echinochloa polystachya* and *Eragrostis maypurensis*. For a more detailed account of the section traversed, namely, from Caracas south-westwards to Calabozo and San Fernando de Apure, reference is made to the article in question. (Myers, 1933.) Humboldt in his travels collected the following plants: *Kyllinga monocephala*, *K. odorata*, *Cenchrus pilosus*, *Sporobolus tenacissimus*, *Trachypogon plumosus*, *Panicum micranthum*, *Eragrostis reptans*, *Paspalum leptostachyum*, *P. conjugatum* and *Aristida recurvata*. (Humboldt, quoted by Myers, 1933.)

Pittier, Chase and Luces visited the eastern Llanos in 1940 at the end of the dry season (March 21 to April 8), making their headquarters at Santamé near the Tigre river in the state of Anzoátegui. They found that in vast stretches the dominant grasses are *Trachypogon plumosus*, *T. montufari*, *Aristida riparia*, *A. cognata*, *Paspalum gardnerianum*, *Axonopus anceps*, species of *Axonopus* without inflorescence, and *Arundinella hispida*. None of these are good forage grasses; they are coarse, and probably dominant as the result of the yearly burning of the Llanos. Mixed with them are the following, all with some forage value: *Andropogon hirtiflorus*, *A. selloanus*, *A. bicornis*, and a few other species; *Elyonurus adustus*, *Sporobolus cubensis*, and *Axonopus purpusii* found to be closely grazed where there were cattle. The last-named grass endures extreme drought and spreads by vigorous stolons. It may prove to be a good forage grass, but it produces little seed and would have to be propagated by cuttings of the stolons. An experimental planting has been made. (*Chron. bot.* 1941.)

MESA DE GUANIPA

Since the foregoing account appeared Pittier has published a phytogeographical essay descriptive of the region concerned, a high tableland (maximum altitude 300 m.) named the Mesa de Guanipa. An account is given of five types of vegetation, namely, arrow grass savannahs, periodically flooded savannahs, *Mauritia* associations both marshy and dry, and the plant cover of the river Cári region and of the vicinity of Pariaguán respectively.

ARROW GRASS SAVANNAHS

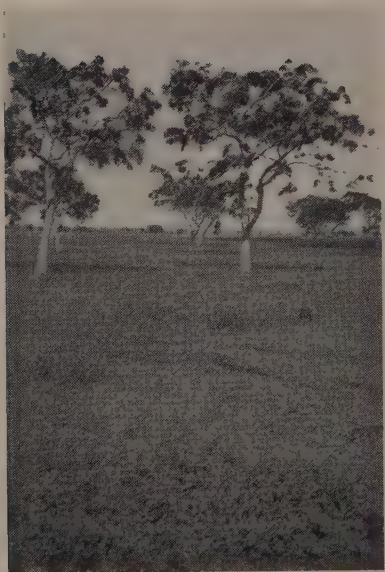
The arrow grass savannahs are comprised mainly of some forty-four species of grasses, of which five, *Leptocoryphium lanatum*, *Trachypogon vestitus*, *T. montufari*, *T. plumosus*, and *Axonopus chrysodactylon* are, in different associations and under different conditions, dominant. The *Trachypogon* species, like *Diectomis fastigiata* and some species of *Aristida*, are known as arrow



PL. 7. BRAZIL. Natural grasslands or "campos" used for cattle ranching, with fringe woodlands along the watercourses, 18 miles west of Guarapuava, State of Paraná. (*Photograph by J. L. RICH. 1942. Courtesy American Geographical Society*)



PL. 8a. VENEZUELA. The Llanos. Palm savannah. (Photograph by H. PITTIER)



PL. 8b. VENEZUELA. Mesa de Guanipa, in the Llanos. Savannah with the tree *Byrsonima crassifolia*. (Photograph by H. PITTIER)



PL. 8c. VENEZUELA. Woodland containing *Cereus*, Anzoátegui, in the Llanos. (Photograph by H. PITTIER)



PL. 9a. VENEZUELA. Mesa de Guanipa, in the Llanos. Savannah, *Mauritia minor* in the background. (Photograph by H. PITTIER)



PL. 9b. VENEZUELA. Mesa de Guanipa, in the Llanos. Savannah, *Mauritia minor* and associated species in the background. (Photograph by H. PITTIER)

grasses on account of the sharp, penetrating point at the base of the florets. The arrow grasses are not eaten by stock, and the points, when the grasses are in flower, are frequently the cause of severe inflammation and have even been known to penetrate the lungs of animals. Five species of tree are found at intervals in this savannah, their occurrence coinciding with almost imperceptible elevations in the land. The spacing of *Byrsonima crassifolia* on slight elevations of this kind is shown in Pl. 8b. The grass associations have in many parts the illusive appearance of close artificial sowings in straight lines running parallel with the direction of the wind. The scarcity of better grass species is occasioned by the periodic routine burning to which the area is subjected. This finding was deduced from a study of roadside slopes which escape the fires, where *Eragrostis maypurensis*, *Gymnopogon foliosus* and several other species not visible in the neighbouring savannah were found. Certain petroleum companies working in the Guanipa tableland prohibit burning in the vicinity of their works, and in a few years' time it will be possible to make more satisfactory comparison of the plant cover of the burned and protected areas. A catalogue of the plants found comprises, in addition to the forty-four grasses mentioned, some sixty-five other plants including twelve species of the Cyperaceae and sixteen of the Leguminosae. Most of the savannah plants proper have special adaptations enabling them to resist long periods of drought and intense insolation. The roots are either single, thick, and deeply penetrating or else much branched and spreading. The first type was observed in species of *Phaseolus* and *Eriosema*, while in *Galactia jussieuana*, another leguminous plant of which isolated examples were found, all the root system was found in the shallow black soil layer below the shifting sand, with one tap root, not much thickened, penetrating vertically for over 1 m. and several horizontal roots, one of which was traced for a length of over 2.5 m. Nodule bacteria were present. The desirability of studying the root systems of savannah plants is stressed.

PERIODICALLY FLOODED SAVANNAHS

This formation was observed on the left bank of the river Cáni. It covers a large plain and differs widely from the surrounding savannahs. The *Trachypogon*, *Axonopus* and *Aristida* species so conspicuous in the latter become rare and are replaced by finer and more delicate grasses, most of them good for feeding stock. Among those listed are *Mesosetum chaseae* and *Paspalum* species (*P. convexum*, *P. finbriatum*, *P. maculosum*, *P. millegranum*, *P. pumilum*). During the rainy season this area is almost entirely submerged, but in the summer the ground dries again and the savannah suffers the general aridity of the region.

PALM SAVANNAHS

The palm savannah is a formation frequently seen in the Llanos, where it is generally indicative of moist conditions. (See p. 119 and Pls. 8a, 9a and 9b.) The dominant palm has been called *Mauritia flexuosa* hitherto, but Pittier has questioned this name and the palm has now been identified by A. Dugand, Director of the Institute of Natural Sciences, Bogotá, as *Mauritia minor* Burret (*Caldasia*, 3. 17-21, 1941). The *Mauritia* formation is far from being monotypical. In its most characteristic form *M. minor* is accompanied by another palm, *Euterpe stenophylla*, together with a species of *Bactris*, *Montrichardia arborescens*, an aquatic plant, and *Miconia palmetorum*, a shrub 1 to 3 m. in height. In this type the formation is a woodland, and it nearly always accompanies the rivers of the eastern Llanos, varying in width from a few hundred metres on each river bank on the tablelands to 2 and even 3 km. along the lower Orinoco. In the immediate vicinity of these palm grove fringes there are moist, spongy lands, exposed to occasional flooding, carrying an abundant and varied flora. The base of this association is formed by grasses and dwarf Cyperaceae, but many other species, including four legumes, are somewhat sparsely intermingled with the grasses. The arrow grasses are absent; six species of *Panicum* and six of

Paspalum are recorded among the species listed, and among the legumes *Desmodium adscendens* and *D. barbatum*.

There are also "dry" palm groves, where *Mauritia minor* and other palms flourish in alluvial soils without appearing to suffer from the periodic absence of surface water. *Aristida setifolia* is abundant in the open spaces, and thirteen other grasses are listed. (Pittier, 1942.)

GRASSES IN RELATION TO ALTITUDE

In 1937 Pittier made a study of the grasses found in the different altitude zones of Venezuela, and this was brought up to date by Luces in 1942. Of the 112 genera and 441 species recorded, by far the greater number are listed for the hot zone which contains the Llanos.

NUTRITIVE VALUE

Pittier's 1937 report contains some useful information on the nutritive value of some of these species, as does also a recent study by Luces of the Venezuelan grass genera. (Luces, 1942c). In 1926 Pittier wrote that probably many of the indigenous grasses could with advantage be selected and propagated for the benefit of the stock raiser. He noted at the same time that regular use was made by the grazing animal of plants other than herbage plants, but that careful observation would be necessary to determine exactly which shrubs and trees were used and which rejected. In the meantime he drew up a list of species found by himself and various farmers to constitute naturally grazed plants, and of these the following belong to the hot zone:

Gramineae, *Panicum maximum*, *P. laxum*, *Paspalum plicatulum*, *P. vaginatum*, *Guadua latifolia*, *Eleusine indica*, *Chloris radiata*, *Ch. polydactyla*, *Trachypogon plumosus*, *Cenchrus brownei*, *Axonopus compressus*, *Leersia hexandra*, *Paspalum conjugatum*, *P. notatum*; Leguminosae, *Vigna luteola*, *V. vexillata*, *Phaseolus* sp., *Pithecolobium ligustrinum* (leaves eaten), *Samanea saman* (fruits eaten), various species, trees and shrubs, of *Piptadenia*, *Mimosa*, *Acacia*, and *Prosopis*, (fruits eaten); Vitaceae, *Cissus sicyoides* (fruits eaten); Malvaceae, *Sida rhombifolia*; Sterculiaceae, *Guazuma ulmifolia* (fruits eaten); Moraceae, *Trophis americana* (leaves eaten). (Pittier, 1926, pp. 51-2.)

In his study of the Guanipa tableland, Pittier lists the following species as reputed to be good herbage: *Antheophora hermaphrodita*, *Digitaria sanguinalis*, *Eragrostis viscosa*, *Panicum fasciculatum*, *P. laxum*, *P. molle*, *P. pilosum*, *P. versicolor*, *Paspalum pumilum*, *Reimarochloa acuta*, *Sporobolus indicus*, *Bulbostylis junciiformis*, *Oncostylis paradoxa*, *Desmodium asperum*, *D. barbatum*. Four species are said to be rejected by animals, namely, *Aristida pittieri*, *Paspalum plicatulum*, *Trachypogon plumosus* and the arrow grasses in general, and *Leptocoryphium lanatum*. (Pittier, 1942.)

USE

The sixteenth century explorers found in the Llanos absolutely virgin land uninhabited by Indians, who had no domestic animals and grew subsistence crops in the forested delta of the Orinoco or in the uplands. The sight of these immense grasslands naturally suggested the formation of large herds. Cattle were introduced in 1548, they multiplied rapidly and by 1812 approximately 4,500,000 head are estimated to have been living in a semi-wild condition under the care of "llaneros" or cattlemen who were the counterpart of the Argentine "gauchos". To the advantage of practically illimitable grazing areas the Orinoco plains added the still more important advantage of a complete absence of carnivorous enemies. The great drawbacks of the Llanos, however, were, and are, the alternation of floods and droughts and the prevalence of animal diseases induced by mosquitoes, ticks, and other pests of tropical regions.

During the rainy season of five months, so heavy is the rainfall that the rivers are unable to carry off all the flood waters, and vast expanses of land, especially in the neighbourhood of the Orinoco, are inundated. Only the low tablelands, which stand like islands above the flood, are available for cattle. When one such island is grazed bare, the cattle are driven through shallow water to another, or the herds are taken to higher ground between Calabozo and Valencia. (James,

1941.) One reads of animals swimming from one island to another in their endeavours to find feed, and it is even reported that many perish in attempts to reach hummocks of ungrazed grasses. (Jones and Darkenwald, 1941.) James has estimated that "without some form of protection against floods, the maximum potential amount of cattle which the llanos will support is limited by the extent of these areas which remain above the floods". (James, 1924. Quoted by Finch and Trewartha, 1936.)

During the dry season the floods recede, the smaller rivers are reduced to chains of swamps and pools, the tall savannah grasses turn brown, hard and inedible, the trees of the scrub forest lose their leaves, the higher lands with their light, sandy soils become very dry and the herds of cattle must be driven far south to the wet spots near the Orinoco. "Only when the young green shoots of grass appear at the beginning of the rainy season or in the stagnant waters of the receding floods can cattle find satisfactory pasturage, and even then the native grasses are low in food value. Most of the year the herds barely avoid starvation." (James, 1941.)

BURNING

At the end of the dry season the dried grasses are regularly burned in order to make young herbage available for the hungry cattle (James, 1941), and this practice has undoubtedly contributed materially to change the nature of the plant cover, which is probably very different to-day from that into which the first graziers turned their animals in 1548. Chase writes that burning the Llanos "has diminished the better grasses, until much of the eastern llanos, at least, are occupied by inferior ones which are more resistant to elimination by fires. . . . The dominant grasses, those that have withstood the combined effects of wind and water, drought and burning, are *Trachypogon plumosus*, *Axonopus anceps*, both coarse and hairy, giving a grayish cast to miles of the llanos, *Paspalum gardnerianum*, and species of *Aristida*, all of little or no forage value, except when very young". (Chase, 1944.)

Pittier says that even in the virgin savannahs the proportion of forage herbage has become reduced to a minimum, the greater part of the grasses being more suitable for paper making than for fodder. Instead of being improved by time and the efforts of those interested in animal husbandry, the Llanos have been rapidly deteriorating, principally on account of the periodic fires to which they have been subjected. Pittier is a stout enemy of burning, concerning which he writes as follows: "Fire, in the common opinion, suppresses the remains of the old grass, provokes the rapid growth of tender, green herbage palatable to cattle and, finally, destroys ticks and an innumerable quantity of other insect pests. These, almost without exception, are so many errors. It is true that the devouring flames make a clean sweep of the vegetation of the savannah, but through the very nature of this vegetation this work of destruction is eminently selective in an adverse direction. The nutritive plants are of two classes: firstly, delicate dicotyledons belonging to the family of the Leguminosae, and then small grasses, creeping and lost among the taller grasses. These two categories of plants are ill-equipped to resist fire: being of small size they burn readily, and their roots are so superficial that fire annihilates them. The coarse grasses, on the contrary, and the weeds which commonly invade grazings burn with difficulty and their deep roots are resistant to passing fire. Thus the immediate result of the fire is the suppression of the nutritive plant growth and the development of the useless plants: the cattle, being thus increasingly badly fed, give less milk and their meat becomes fibrous, dry, and almost uneatable.

"The belief that fire suppresses the tick is another error. Certainly the greater part of those actually present in the savannah disappear at the time of burning, but the propagators of the pest are the cattle themselves, and while the destruction of this parasite is not effected by the rigid application of well-known methods of control the evil will remain without remedy; the animals

will continue to be exhausted by loss of blood and infected by the pathogenic germs of which the tick is the principal transmitter.

"Besides injuring the vegetation, fire ruins and sterilizes the soil. Whatever may be said concerning its utility and its alleged necessity, fire is the excessively active servant of the lazy and negligent man, but never his benefactor. The only method of improving grazings is through the eradication by hand or by machinery of useless or injurious plants, and the encouragement by all means of rooting and development in the useful plants." (Pittier, 1926.)

Myers is disposed not to attach so much importance to the action of fire, saying that although there can be no question that fires have been much more frequent on the Llanos since the advent of man and especially of civilised man, the original vegetation was adapted to sweeping fires before the discovery of America. "A change of probably considerably greater influence was the introduction of close-grazing European animals—horses and cattle—which now roam the llanos in tremendous numbers. . . . During the dry season much of the plains is obviously overstocked. We found the wide margins of many ponds and streams eaten as smooth as a billiard table. Undoubtedly the vast areas, in the drier localities, of the aromatic Labiate *Hyptis suaveolens*, and, in wetter places, of the Convolvulaceous bush *Ipomoea crassicaulis*, are due to selective feeding on the part of the stock, and represent a by no means negligible deterioration of the llanos as pasture." (Myers, 1933.)

That deterioration has taken place is clear. Chase writes, however, that even under the adverse conditions observed by her in the eastern Llanos in the dry season there were a few good forage grasses which might increase if given some encouragement. One relative of *Axonopus compressus* or carpet-grass, *Axonopus purpusii*, with long stolons clinging to the windswept earth, appeared promising and was seen to be grazed by the few cattle present. Near the groves of *Mauritia minor* bordering the rivers were seen species of *Paspalum* and *Andropogon* that would furnish fair-to-good forage. Farther east, in gullied and deeply cut land, strong coarse grasses were seen, enough to reclothe the land if burning were prevented. In her view "with such protection", namely, the suppression of burning, "the more valuable grasses may be expected to spread and again support herds of cattle". (Chase, 1944.)

PRESENT TRENDS

In spite of the very considerable drawbacks to ranching on the Llanos, the cattle industry of this region is one of the most persistent of all the forms of Venezuelan economy. For historical and other reasons it has passed through periods of decay, and the counts of cattle in the various years reveal an extraordinary degree of fluctuation, as follows :

1812	...	...	...	...	4,500,000
1823	...	...	...	...	256,000
1883	...	...	...	over	8,000,000
1920	...	...	...	below	3,000,000

At the present time, however, the industry appears to be distinctly on the upgrade.

Up to the present, the cattle produced are mainly store cattle. The chief markets are northern Venezuela and highland Colombia. For home consumption cattle from the Llanos are generally fattened on upland, wet pastures about the Lake of Valencia. Those going overland to Colombia receive much-needed forage on irrigated pastures of *Medicago sativa*, *Panicum purpurascens* and *P. maximum*, situated near the foothills of the Andes. From the eastern region a certain proportion are shipped via the Orinoco River to the West Indies for store cattle or low-grade meat. (James, 1941. Jones and Darkenwald, 1941. Pittier, 1926 and 1939.)

A spirit of progress is now abroad in Venezuela. In the stock-raising industry it is being expressed in endeavours to improve the quality of the animals kept and to improve dairying, wherein it is realized that for improved stock improved feeding is necessary. A Commission is engaged in surveying the natural resources of the country; an official agrostologist, especially trained for the purpose, has been appointed to the Ministry of Agriculture; and the study of herbage and forage crops is included in the investigations of the national agricultural experiment stations established in different parts of the country. It is improbable that the problems of the Llanos will remain untouched.

(ii) The Colombian Llanos

East of the great Andean range known as the Eastern Cordillera that transects Colombia from north to south, lies the Colombian part of the Llanos. It is divided by a western projection of the Guiana Highlands from the great Amazon plains farther south, and together with them comprises almost two-thirds of the total area of Colombia. Both the Orinoco and the Amazon plains are, however, very sparsely inhabited, in some parts solely by Indian tribes which have a large degree of independence. The principal plant cover of the Amazon region is dense tropical forest. The Llanos or Orinoco plains represent, however, potential grazing lands of great magnitude.

In climatic and other environmental conditions the Colombian Llanos closely resemble those of Venezuela, being indeed a continuation of them, and the plant cover, apparently, is similar also although possibly less affected by the biotic factor since the stocking of these lands is sparse. The mean temperature, to about 500 metres above sea level, ranges from 27° to 30° C. (Dugand, 1942.)

USE

Of the 8,112 thousand head of cattle recorded for Colombia, only 300 thousand are found in the eastern Llanos (1938 figures). Most of these cattle are in the Departments of Boyacá and Meta, territorial divisions nearer the more closely populated highlands of Colombia. Grazing lands may be rented very cheaply in these regions. Wylie considers that the Colombian Llanos could be the largest cattle-grazing region of the country if the transportation problem could be solved. (Wylie, 1942. James, 1941.)

IMPROVEMENT

Rueda and Reyes indicate that, in the Colombian Llanos also, problems similar to those found in the Venezuelan plains are encountered. Their grasslands are natural savannah, composed of indigenous grasses of little nutritive value which soon become very fibrous. For this reason they are periodically burnt, to be regazed when they shoot afresh. With the firing the plant cover becomes reduced and the soil loses its fertility, and it is considered that only the sowing of good herbage, fencing, and the supplying of drinking facilities can deliver these lowlands from serious injury. Transhumance is often necessary on account of intense droughts in summer and inundations in winter.

These authors urge the desirability of more fencing to ensure the better use of grazings and to remove some of the main defects of animal husbandry in the country, namely, inadequate care of stock, insufficient hygiene, lack of culling, and imperfect breeding. Standardized barbed wire is obtainable at low prices through the Government Department of Agricultural Credits.

Of the grasses useful in these lands, special mention is made of *Panicum purpurascens*, which has been widely propagated in the moist regions of the hot zones and promises to develop satisfactorily in the eastern lowlands; *P. maximum*; and *Hyparrhenia rufa*, which has great drought-resistant properties. (Rueda and Reyes, 1941.)

The carrying capacity of the lowland savannahs is estimated as 1 head of cattle to 4-7 acres (1.62-2.84 ha.), and the weight of the finished animal as 880 lb. compared with 1,025 lb. on the highland plateaux. It takes four or five years to produce marketable animals. The cattle are at the outset of low grade, and the chief market for the Llanos is the Bogotá region, reached by long overland mountain drives which greatly reduce the condition of the animals. One of the chief problems of the Colombian Llanos is that of transport. (Wylie, 1942.)

TYPE 4. SAVANNAHS OF HOT CLIMATES

(b) **Bolívar savannahs of Colombia and the lowland savannahs of Costa Rica**

The Bolívar savannahs of Colombia and the western, lowland savannahs of Costa Rica occupy an unusual position among the savannahs of tropical Central and South America because, unlike most of the others, they have not remained mere breeding grounds of rather poor quality store cattle but have already become of vital importance in supplying the meat requirements of the countries in which they are situated.

(i) The Bolívar savannahs

SITUATION AND CLIMATE

The Department of Bolívar occupies 22,996 square miles of land in the north of Colombia and has a long sea coast on the Caribbean. It lies west of the great waterway of Colombia, the river Magdalena, and consists of a vast lowland plain having an altitude that seldom exceeds 200 metres. Although east of the Magdalena much of the land is permanently flooded, west of the river, in Bolívar, while large areas disappear under water during the floods they dry out again during the dry season (October to March), at which time they are used for grazing.

The coastal lowlands up to an altitude of 350 metres are hot, having a mean temperature ranging from 27° to 30° C. Fluctuations of temperature throughout the year are comparatively small. Rainfall is very irregular and unevenly distributed, averaging from 300 to 4,350 mm. in 22 to 145 days, with one annual period of utter drought lasting from three to five months. Dugand, of the Institute of Natural Sciences, Bogotá, gives the following description: "The country is level or moderately hilly and rolling, generally semi-arid and open, partly marshy along the rivers, and covered with a vegetation of shrubby trees and clambering vines growing in thickets, and scattered groves of short-barked deciduous trees. It is not much forested except in the vicinity of streams and on protected hill-slopes or bottomlands, and large areas consist of grassy savannahs." (Dugand, 1942.)

USE

And yet it is this apparently unprepossessing region that Jones and Darkenwald describe as containing "the most useful savannahs of South America". They are said to resemble other savannahs, but to have somewhat better grasses. (Jones and Darkenwald, 1941.) The most important part of the Department's grazing lands is composed of a coastal strip, 40 to 75 miles (64.5 to 120.7 km.) wide. Behind this lie the savannahs of the Magdalena and Sinu river valleys.

The total grazing area of Colombia is about 65 million acres (26,300,000 ha.) or 23 per cent of the entire land area. Of this, over one-half is contained in the Department of Bolívar, for which were registered 1,756,000 of the country's 8 million cattle in 1938. This number is much larger than that recorded for any other administrative division of the country and in striking contrast to the 300,000 head of cattle registered for the great Orinoco plains with their approximately similar climatic conditions. Ranches in Bolívar are small compared with those in Argentina or the western United States. The chief markets for Bolívar cattle are the Caribbean ports and the more highly

populated highland interior of the country via the town of Medellín. Animals travel to these markets overland on the hoof or in cattle barges on the Magdalena and other rivers. There is little exporting of meat or cattle from Colombia. (Wylie, 1942. Jones and Darkenwald, 1941.)

PLANT COVER

The most important grasses of the Bolívar savannah are undoubtedly *Panicum purpurascens* (Pará grass) and *P. maximum* (Guinea grass). Rueda and Reyes report that the former is the most widely propagated grass in the humid regions of the hot lands. Guinea grass is widely diffused in the hot regions not liable to flooding, and its growth is admirable in Colombia, but as a rule it should be used at an earlier, more tender stage than is at present customary, in order to avoid having recourse to burning when the seed is allowed to ripen. "Jaragua" (*Hyparrhenia rufa*) and a grass described as "puntero" are being propagated in the hot lands for their drought-resistant qualities, said to be greater than those of *Panicum maximum*, and for smothering weeds. Other grasses mentioned by Rueda and Reyes are *Melinis minutiflora*, which has proved of signal service in covering slopes where water retention is very poor, in suppressing weeds, preventing erosion, forming a plant cover rapidly and by means of its oily secretion restricting the proliferation of ticks; the so-called "grama" grasses, commonly species of *Paspalum*, which form short swards and are highly esteemed for their nutritive value, their resistance to trampling and their capacity for association with legumes; and *Axonopus scoparius*, named "micay", which is said to be useful for fattening and milk production. The last-mentioned grass is a native of Colombia, its name being that of the locality in the Pacific lowlands from which it emanates. (Chase, 1945.)

ANIMAL BREEDING

The Bolívar cattle are subject to a serious amount of disease, generally pest-induced, and the mortality among calves is especially high. The Colombian Government has established veterinary stations to study this problem and is also endeavouring to meet the situation by encouraging planned breeding. Herein efforts are made to increase in the native stock, descended from that brought by the sixteenth-century colonists, resistance to tropical conditions through the infusion of Zebu blood, after which it is hoped that crossing with more productive, European stock will become possible. Attempts to cross the native directly with European stock have proved costly and unsuccessful. (Rueda and Reyes, 1941.)

(ii) The lowland savannahs of Costa Rica

It has been noted already that the central highlands of Costa Rica, where the majority of the population lives, are unable to supply the country's meat requirements, and these are met for the most part by the ranches of the Pacific lowlands, notably those in the province of Guanacaste.

SITUATION AND CLIMATE

The altitude of the Guanacaste grasslands is from 0 to approximately 750 metres above sea level. The temperature is that of tropical heat, but exact records are not available, and this factor appears to be of less significance for the cattle industry than rainfall. There are two seasons, the winter or wet season lasting from May to November, the summer or dry season from December to April. Records kept on three stations from 1926 to 1939 show a range of 41 to 120 inches (1,041.4 to 3,048 mm.) in the annual rainfall for these years. Frequently there are unusual periods of drought and of excessive rainfall. In general, stock is moved from the lowlands to the uplands during the wet season, when much of the lowlands—up to one-fifth on some ranches—is unusable. (Becker, 1943.)

PLANT COVER

In the annual report of the National Centre of Agriculture for 1938 it is stated that the natural grasslands of the Pacific lowlands are normally of two types, comprised respectively of tall grasses such as *Panicum maximum*, *Hyparrhenia rufa* and *Panicum purpurascens*, and of short grasses such as *Paspalum notatum*. There is a deficiency of herbage legumes, for which the practice of periodic burning to induce fresh shooting is held responsible. (Orozco, 1939.)

As in the Bolívar savannahs, Pará grass (*Panicum purpurascens*) is of great value for low, wet soils, whereas Guinea grass (*P. maximum*) is more successful in the drier lands. "Gramma" grass (a species of *Paspalum*, possibly *P. notatum*) and a native grass, "jaragua" (*Hyparrhenia rufa*), which can be sown by broadcasting seed, are used as supplementary pastures, especially on well-drained hillsides. "One ranch with large areas of lowland has approximately the following acreages of planted pasture of these four main types: Pará, 3,000-4,000; Guinea, 2,000-3,000; jaragua, 2,000-3,000; grama, 500-1,000." (Becker, 1943.)

PANICUM PURPURASCENS

In passing, the value and persistence of Pará grass, *Panicum purpurascens*, in low-lying, hot and wet savannah may be noted. This grass, which is a native of Brazil, is variously termed *Panicum purpurascens*, *P. barbinode*, *P. guadaloupense*, *P. equinum*, *P. pictigluma*, *P. paraguayense*, *P. numidianum*, *P. muticum*, and *P. molle*. (Hitchcock and Chase, 1910. Corrêa, 1926.)

Becker (1943) stresses its usefulness in the Costa Rica lowlands, where it constitutes one of the chief components of the lowland fattening pastures, and says that when it is ploughed up periodically to kill weeds and loosen the soil, it will grow again. Its value in the Colombian lowlands has already been noted by Rueda and Reyes (1941). Itié has traced its progress in Mexico, into which country it was first introduced about 1856. Pará has been cultivated there as a pasture grass and may now be regarded as completely naturalized. It is found spontaneous in all the so-called hot lands and even up to an altitude of 1,000 to 1,500 metres, occupying its natural habitat, namely typically hygrophilous localities such as the banks of watercourses, somewhat marshy depressions, and localities subject to periodical inundation of fairly long duration. (Itié, 1939.) Watkins writes that this grass plays a very important part in the forage programme of El Salvador, the Central American republic situated to the west of Honduras, where its fast-growing habit, high yields and nutritive value make it one of the country's superior grasses. (Watkins, 1946.) Smith gives an account of methods of planting in the coastal lowland areas of Mexico. "In the coastal areas, pastures planted to Pará and Guinea grasses are usually well cared for and conserved. In order to grow these grasses, the land usually is cleared and planted to corn [maize]. The grasses are then planted between the corn rows. In planting Pará grass, the workman goes down the corn rows with a bunch of the grass under his arm and drops pieces on the ground, covering them with the soil. Guinea grass is propagated by seeds sown in little furrows between the corn rows. Occasionally, these grasses are planted on newly cleared land. Usually in the following spring the grass is burned over to remove any remaining brush, stubs, or other vegetation; it is then able to withstand competition from almost any other vegetation." He adds that both grasses "grow luxuriantly but are considered only medium in quality for grazing and forage"; nevertheless they are the grasses most commonly used in these regions. (Smith, 1944.)

USE

The Guanacaste pastures are of two kinds, planted or improved pastures and native range lands, often forested: the carrying capacity of the latter is very varied, for from 10 to 20 acres (4.05 to 8.1 ha.) or more are necessary to maintain one full-grown head of stock. In contrast to the

central highlands of Costa Rica, where small holdings are the rule, in Guanacaste large ranches, worked by cowboys, are usual. The area is sparsely populated, but the cattle comprise over 40 per cent of the total number of cattle in the country. The quality of the animals is being gradually improved by the infusion of Brahman and Hereford or other imported blood.

In addition to the normal difficulties of the cattle owner in the tropics, namely, irregular rainfall, floods, droughts, pests and animal disease, the grazier in Guanacaste also has to reckon with depredations by jaguars in the forested uplands and attack by alligators in the vicinity of low-land streams, disadvantages which are absent in, for example, the Venezuelan Llanos. Information on the tick problem in Guanacaste is given on p. 202.

More or less modern methods appear, nevertheless, to have achieved a considerable degree of success, and the transport problem appears to be less formidable than in Colombia or Venezuela. All the Guanacaste cattle at present produced are absorbed by the closely populated central highlands of Costa Rica, and the animals are conveyed thither first by boat and then by rail, whereby the loss of condition entailed in long, overland drives is avoided. (Becker, 1943.)

The Government Agricultural Station is envisaging measures for the protection of the herbage legumes (often destroyed in excessively wet years or through the practice of firing) and for the selection and distribution of suitable herbage and forage plants. (Orozco, 1939.)

TYPE 4. SAVANNAHS OF HOT CLIMATES

(c) Savannahs of the Amazon basin and of the Guianas

The great Amazon region is generally regarded as one vast forest, but, although it does actually constitute the world's largest area of tropical rain forest, numerous interruptions of the thick cover of trees exist in the form of grassy savannahs. It has been reported by Luetzelburg, who accompanied a Brazilian Government Expedition to Amazonas, that the savannahs are becoming increasingly widely extended at the cost of the forest with which they alternate. This is largely on account of savannah fires, the heat from which is very intense and is destructive of the adjacent forest vegetation. (Luetzelburg, 1939.)

AREA

The aggregate size of these scattered savannahs is very considerable. Figures are not available except in the case of the northern, Rio Branco area which Luetzelburg estimates as approximately 50,000 square kilometres, but an impression of the extent of at least some of them may be obtained from James' map of the natural vegetation of the Amazon and Guiana coast. (James, 1941, p. 545.)

CLIMATE

Temperatures in the Amazon region are not excessively high but are disagreeable on account of their monotony. At Santarém the annual average recorded is 78.1° F. (25.6° C.), with a range of only about 4°F. between the average of the warmest and coldest months. Rainfall for the whole region is heavy, but there is a so-called dry season or summer, July to December, in which there is a partial or entire absence of rain. "In both rainy and dry seasons precipitation comes in the form of violent showers, followed by sudden clearing." The humidity of the region is its most unpleasant climatic feature, especially in places protected from the wind. (James, 1941. Domingues, 1941b). A full account of climatic conditions is given by Luetzelburg (1939) with special reference to the forests.

SITUATION

The most important Amazonian savannahs are situated in the north-east on the Rio Branco towards the frontier of the Guianas, and in the lower Amazon reach between the great Rio Negro

and Rio Xingú tributaries, which is a zone of lower rainfall and strong winds in the dry season. In the eastern part of the latter region, namely, that in the State of Pará, the dry season is much more accentuated than in the western part in the State of Amazonas, and it is perhaps to this that the presence of numerous savannahs in the Pará region is due.

FLOODED AND DRY SAVANNAHS

The savannahs are of two categories, those periodically flooded and those not liable to flooding. Luetzelburg records a continuous alternation of these types in accordance with the nature of the ground, whether elevated or depressed. Savannahs of the flooded type are found along the littoral and in the lower Amazon region; the most typical have no woody vegetation but a rich herbaceous cover in which grasses predominate. The second, non-flooded type is comprised not only of numerous species of grasses, but also of many legumes and dicotyledons of other families, and is found on clay, yellow sand, or stony soil. All these savannahs are interspersed more or less thickly with shrubs and small trees. The plant species found in them correspond to those found in other Brazilian savannahs, but are much less varied than in those, for example, of the State of Minas Gerais. One series of these "campos" or savannahs follows the Atlantic coast, including the Island of Marajó; another follows the course of the Lower Amazon in the State of Pará; a third is situated a little on the Brazilian side of the northern frontier on the upper reaches of the rivers Branco, Trombetas and Jari; a fourth in the basins of the southern affluents of the Amazon, in the extreme south of the States of Pará and Amazonas. Of these savannahs those of the first and fourth series are distinguished by the presence of *Hancornia speciosa*. Those of the upper Rio Branco and, according to information, those of the upper Trombetas are partly at a high level and dry, partly low-lying and subject to flooding. The savannahs of the Rio Branco have a much more varied flora than the others, being enriched by many species from the north. (Ducke, 1938b.)

Bouillenne, who in 1926 mapped the dry land savannahs of the Amazon region and discussed their ecology, notes that they are confined to the basin of the Lower Amazon, or that part of the river which reaches from the delta as far as the city of Manáos at the junction of the Rio Negro. They extend parallel to the banks of the river, behind the marginal forest and the flooded savannahs, but in addition, their zone, leaving the immediate vicinity of the Amazon, is prolonged northwards towards the Guianas and southwards towards the plateaux of central Brazil.

Bouillenne writes: "The transition from the vegetation of the forest to that of the savannah is clear and abrupt", a finding recorded (for the Guiana savannahs) also by Martyn (1931, p. 19), by Lanjouw (1936, p. 835), and by Smith (1941). Of the vegetation Bouillenne notes that it presents fairly marked xerophytic characters. "The grasses have stiff leaves, assembled in caespitose tufts. The stunted trees have a very small number of large coriaceous leaves which rattle noisily in the wind. The bark of the trees is thick and the wood brittle." Sometimes the trees of these savannahs are low (2 to 10 metres) and isolated from one another, the herbaceous sward dominant; sometimes the trees are grouped together, forming a park; and transitional patterns are also found. According to Bouillenne, the parklike formation is lacking in the Guiana savannahs and is apparently attributable in the Amazon region to greater atmospheric humidity during the dry season. The Amazon savannahs are intersected by fringe forest where there are ravines or watercourses.

The Lower Amazon section of the great river basin enjoys a climate that is relatively dry in comparison with that of the Upper Amazon, and to this fact is due the presence of savannahs. Their localization is considered by Bouillenne to be due to the coincidence of two factors, one the relief presented by the isolated, low hills found only in the Lower Amazon, the other the east wind which in this region is constant and regular throughout the year. The low hills present an obstacle

to the moist Atlantic trade winds and produce thereby rainfall to their east, less rainfall on the hills themselves, and to their west often no rainfall whatever. It is on the areas having the least precipitation that the savannahs are found. The influence of cattle, very potent in regions where they are abundant, is without significance for the maintenance of savannah amid the Amazonian forests. The influence of man is equally negligible. (Bouillenne, 1926.)

Luetzelburg also notes the xerophytic nature of the Amazonian dry land savannah vegetation and the fact that the trees are alien to those of the Amazonian forest proper. (Luetzelburg, 1939.)

Little information on the herbage is available. Domingues (1941*b*) states that most of the savannahs, flooded and otherwise, comprise entirely natural grasslands, having an abundance of grasses and a deficiency of legumes. Spruce records the presence of an extraordinarily large number of different grasses: at Santarém alone he collected ninety different species. (Spruce, 1908. Vol. 1, pp. 145-6.) There is relatively little planting of forage plants, but where this is done the indigenous Pará grass (*Panicum purpurascens*) is that most widely used.

USE

Conditions in the flooded savannahs, at all events, appear to be unfavourable for stock. James describes swampy areas of the flood plain as "little areas of wet savannah on which scrawny cattle graze, knee deep in water". But even to-day the grazing of cattle is the chief economic activity of certain districts, for example, the territory in the vicinity of São Luiz and of Belém. The cattle are pastured on the wet savannahs of the flooded areas, "cattle forced sometimes to swim for their lives during the floods, cattle hardy enough to survive the insect pests of these lowland areas". (James, 1941.)

On the whole, however, apart from semi-intensive dairying in the vicinity of the capital towns, stock raising is haphazard and not industrialized. Horned cattle preponderate; the number of sheep and goats is very small, but some pigs, saddle horses and asses are kept. Two races of buffalo are reared on a small scale. The only animal products exported are cattle and buffalo hides. (Domingues, 1941*b*.)

The whole of the Amazon region is very sparsely populated and inaccessible, and economic considerations would probably make it easier to further the cattle industry by improving the resistance and productivity of the stock, as is being done in the Bolívar savannah of Colombia and the Guanacaste region of Costa Rica, than by attempting to improve the better savannahs, say, those of the Rio Branco with their richer flora. At the same time, the achievements of the Bolívar and Costa Rica lowland savannahs show how skilful management and the planting of appropriate grasses such as *Panicum purpurascens* in the wet lands and *P. maximum* in the drier lands can enhance production.

UPLAND SAVANNAHS OF THE GUIANAS

Of the upland savannahs of the Guianas Smith has written: "The upland savannahs occupy an extensive area in south-western British Guiana and are doubtless continued to the east in a more broken form in southern Surinam and French Guiana; they are an eastward extension of the vast savannahs of Venezuela and the Rio Branco region of Brazil. With an elevation of 100-150 m., these upland savannahs often have an undulating surface, here and there broken with granitic masses which are sometimes, like the Kanuku Mountains, extensive and heavily forested. Rainfall probably does not much exceed 1,500 mm. annually, occurring essentially all within four months; therefore these appear to be true climatic savannahs. They are, for the most part, bunch-grass savannahs, the principal grasses being species of *Andropogon*, *Cymbopogon*, *Trachypogon*, *Elyonurus*, *Paspalum*, *Arundinella*, and *Heteropogon*. Among sedges, which in places are more dominant

than grasses, are species of *Cyperus*, *Carex*, *Hemicarpha*, *Dichromena*, *Scleria*, and *Mariscus*. Toward the beginning of the wet season numerous subprostrate legumes, such as *Grimaldia hispidula*, *Chamaecrista flexuosa*, *Indigofera pascuorum*, *Eriosema lanceolatum*, and *Tephrosia cinerea*, are noteworthy. . . . The predominant woody plant is *Curatella americana*". (Smith, 1941.)

In 1936 Lanjouw made an ecological and floristic study of the Surinam savannahs. He considers this vegetation to constitute a "fire climax". Myers also, writing of upland savannahs of Brazil and British Guiana, says: "All this savannah vegetation seems to correspond to a fire climax". (Myers, 1936, p. 182.) Beard, however, writes: "Burning occurs on savannahs in the Americas, but is held by the writer to be an effect rather than a cause". (Beard, 1944.) Pulle (1938) writes in agreement with Lanjouw, although he adds: "I do not mean to say that everywhere in Surinam the boundaries of the savannah are limited by fire. In some places the constitution of the soil certainly determines the kind of vegetation".

Pulle draws attention to another type of savannah, of vast extent, discovered in the southwestern boundary land between Brazil and Surinam (or Dutch Guiana). A small collection of plants brought back by a boundary expedition contained many species until then unknown for Surinam and not found in the more northerly savannahs described by Lanjouw and others. (Pulle, 1938.)

For a description of the upland savannahs of British Guiana reference is made to work by Martyn (1931) and by Myers (1936). The savannahs of British Guiana are very little stocked, in some places not at all. It is not known to what extent the Surinam savannahs are grazed. Myers records very interesting observations, made under unusually dry conditions, of selective grazing by cattle and horses. On open *Trachypogon* savannah *Byrsonima verbascifolia* was the first favourite of bullocks, and second came fresh shoots of grass or sedge, almost any species, springing from recent burns, although within these *Axonopus anceps*, *Sporobolus cubensis* and *Paspalum lachneum* were favoured, and after them *Trachypogon plumosus*. Horses greedily ate a species of *Indigofera* which resembles *Medicago sativa* in habit. (Myers, 1936.)

Martyn describes the Waranama savannah vegetation, British Guiana, as of poor feeding value, a finding confirmed by Follett-Smith (1930), who analysed both the soils and the grasses of the same region and found the former to consist mainly of an acid sand deficient in lime, phosphate, potash and organic matter and the grasses to be markedly deficient in essential minerals. Bone (1930) says that the only present qualification of the savannah as a ranching area is an excellent water supply, and notes clinical evidence of phosphorus deficiency in the animals from the region, for which he recommends supplying licks of one part salt and three parts bone meal. Martyn thinks it might be possible to improve the herbage by retaining the cattle in certain selected areas and establishing a regular system of close cropping, or by introducing forage plants of higher feeding value than the indigenous flora. (Follett-Smith, 1930. Bone, 1930. Martyn, 1931.)

While these findings apply to the Waranama savannah of British Guiana, it is probable that they are applicable also to the savannahs of Surinam and French Guiana and of the belt of similar savannahs, broken at intervals, which, according to Martyn, spreads across northern South America, north of the Amazon, from the foothills of the Andes nearly to the Atlantic.

TYPE 4. SAVANNAHS OF HOT CLIMATES

(d) The savannahs of Bolivia, Mato Grosso, and the Gran Chaco

BOLIVIA

Relatively little effective use appears to be made of Bolivia's enormous areas of savannah. A certain amount of stock raising exists, but it is apparently of a somewhat desultory nature. The number of cattle in 1931 is estimated as 2,064,300 for the whole country, and it has been stated

that "some quarter-million wild cattle range the llanos, descendants apparently of Spanish cattle escaped from La Plata. The grasses and soil of the eastern part of the country would make valuable grazing land. The bullocks are light and yield about 3 cwt. of beef". (South American Handbook, 1941.)

Cárdenas, of the University of Cochabamba, writes: "The llanos of Yacuma and Mojos, covered with grass, which extend as far as the horizon with an impressive immensity like that of the Argentine pampa, could rear illimitable quantities of cattle; but because of their distance from accessible means of communication, their frequent inundation and unhealthy conditions, they continue to constitute a zone without actual value". (Cárdenas, 1941a.) These llanos or plains lie in the northern, riverine lands of Bolivia. They are typical "wet savannahs", and stock raising in them is attended by difficulties similar to those encountered in the Orinoco flood plains. (James, 1941.)

In addition there are the eastern llanos or savannahs of the Department of Santa Cruz and part of the Department of Cochabamba. These eastern plains form a part of the large area, known as the Gran Chaco, which is shared by Bolivia, Paraguay, Brazil and Argentina. (James, 1941, pp. 208 and 276.) James says (p. 212) it is generally believed that the Gran Chaco is physically suited for agricultural and pastoral colonization. Cárdenas writes: "The eastern llanos of Bolivia in a perhaps not very far distant future will be connected up with the southern elevated plain of Brazil, which is considered to-day, together with the La Plata plains and the valleys of Chile, to be among the most flourishing economic regions of South America". (Cárdenas, 1941a.) At present, however, little use appears to be made of them. A great difficulty in this region is the existence of the tick (*Boophilus microplus*). (Parodi, 1945.)

MATO GROSSO

The great savannah area of the Brazilian state of Mato Grosso, situated to the east of Colombia, is used to a very considerable extent, however, and an increasing amount of official attention is being devoted to the region's stock-raising problems.

Domingues, in his classification of the Brazilian grasslands, regards Mato Grosso as a region to itself (see Fig. 11). It is, as he says, a zone having clearly marked characteristics, namely, extensive and partially flooded natural grasslands, and a subtropical climate with a cold and dry winter season that is rainless, and high temperatures in the rainy summer. (Domingues, 1941b.)

CLIMATE

For the purposes of meteorological observation, the Brazilian Ministry of Agriculture includes the state of Mato Grosso in one region together with the grasslands of the state of Goiás (central elevated plain) and the so-called Triangle region of Minas Gerais, namely, the "central region (semi-humid continental type)". A meteorological station is to be established at the town of Corumbá, right in the heart of the Mato Grosso marsh, 19° 0' S. and 57° 30' W., altitude 116 metres, to serve the lowland part of the region; while a second station at Formosa in Goiás, altitude 906 metres, 15° 30' S. and 47° 19' W., will serve the higher central elevated plain. (*Bol. Min. Agric. Brazil*, 1942a.)

SAVANNAHS

Wet savannahs and dry savannahs, tree-scattered or pure grassland, comprise approximately three-fourths of the 1,477,044 sq. kilometres that make up the state of Mato Grosso. Its name, "Great Forest", is therefore somewhat misleading, although the Amazonian forests extend to a little south of 12° S., and forest ribbons follow the river courses. The plant formations are said to be the same as those observed in the more easterly states of São Paulo, Minas Gerais and Goiás.

(Hoehne, quoted by Brito, 1939.) Brito describes Mato Grosso as a natural prolongation of São Paulo from the banks of the river Paraná. It has good watercourses, and extensive grasslands of good natural herbage. Its stock-raising zone extends from the shores of the Paraná on the south and east to the sources of the Paraguay river, where the Amazonian forest is encountered. The huge lowland area east of the river Paraguay and its tributaries is known as the Great Marsh. At times of flood even the higher parts are inundated by water, sometimes to a depth of two to three metres. In due course the water drains off, and grasses and other herbage plants germinate, transforming the swamp into "excellent grazings of great nutritive value" which are used during the dry season. The animals seek refuge in the higher dry savannahs during the wet season. Brito asserts that on account of the periodic flooding these localities are free of warble flies and ticks. On the other hand, Jones and Darkenwald write that owing to the absence of freezing temperatures, which arrest the spread of the tick in cooler lands, it is next to impossible to eradicate it throughout large areas. (Jones and Darkenwald, 1941.)

HERBAGE

The herbage plants of Mato Grosso consist primarily of grasses, and only secondarily of legumes. The most important grasses are species of *Panicum*, then follow representatives of the genus *Paspalum* and various species of *Eragrostis*, *Andropogon*, *Chloris*, *Manisuris* and *Sporobolus*. In the uplands there are wide areas in which *Tristachya chrysothrix* and *T. leiostachya* are dominant. Of the legumes, *Meibomia* species—considered by Brito to be perfect substitutes for the exotic *Medicago sativa*—are found in abundance, namely, *Meibomia pachyrrhiza*, *M. platycarpa*, *M. aspera* etc. There are found also species of the genera *Crotalaria* and *Stylosanthes*. (Bruto, 1939.)

IMPROVEMENT

Domingues (1941*b*) records that the system of stock raising is the most extensive possible, the part played by man being practically confined to the periodic rounding up of cattle. Nevertheless efforts are now being made to encourage the formation of improved pastures, and grass and legume seed is being distributed in Mato Grosso by the Brazilian Ministry of Agriculture. Species mentioned in this connexion are *Panicum maximum*, *P. maximum* var. *gongyloides*, *Meibomia adscendens* and *M. discolor*. (Bol. Min. Agric. Brazil, 1942*b*.)

USE

Ranches are large and herds are large. Jones and Darkenwald speak of "millions of cattle" grazing in the lowland Paraguay river plains of the south-west and the plateau of the eastern area, and note that the animals are on the average poor in quality: "wide of horn, bony of frame, and difficult to fatten, these cattle produce only low-grade meats and extract". Brito, who gives the cattle population of Mato Grosso as 3,500,000 (1936 figures), says the native cattle together with Zebu or Brahman cattle and hybrids are those mainly reared; there are also some Devons and Herefords, but few of the last-named. Transport is by the Paraguay river to the south, and from the higher lands by railway and some good roads to the more densely populated areas of eastern Brazil. A railway exists which connects the eastern shore of the river Paraguay to the Atlantic coast: its projected extension across the Chaco to Bolivia (James, 1941), if carried out, should do much to open up both southern Mato Grosso and the Chaco.

THE GRAN CHACO

The Gran Chaco is a region of scrub forest interspersed with patches of savannah. It extends northwards from about latitude 30° S. into Paraguay, eastern Bolivia and western Brazil. It comprises a lowland plain with a few surface interruptions, and is composed mostly of alluvium

brought by rivers from the erosion of the Andes. Some of the highest temperatures recorded in any part of South America occur in the Chaco, and during the summer rainy season vast areas near streams are inundated. The aggregate area of savannah is very great, but only on the eastern and southern margins are cattle found, raised mainly to supply the needs of the quebracho forest workers, some as store cattle to be sent south to Argentine fattening pastures. Except in the extreme southern area of the Chaco, in Argentina, little is done to improve the stock raised or the nature and management of the pastures, and the greater part of the region, as has been said, is quite devoid of any cattle population. (James, 1941. Jones and Darkenwald, 1941.) For an account of the Argentine Chaco see pp. 67-69. (Parodi, 1947.)

TYPE 4. SAVANNAHS OF HOT CLIMATES

(e) The Cuban savannahs

It has been written of Cuba : " If the vegetation were to be described in two words, these would be savannah and pasture, for the whole central part of the island from the eastern mountains to the western point is savannah in alternation with pasture ". " No single formation covers so much territory in Cuba, or is more typical of Cuban landscape than the savannah. Cuban savannah is usually flat or undulating, non-arable, grass-covered land, often underlaid with serpentine rock. . . . Cuban savannah is bad land. . . . They [the savannahs] . . . rarely make good pasture, for the grass is coarse and wiry." (Seifriz, 1940, 1943.)

The most important savannahs are those situated in the east-central part of the island : they are extensive, have soil poorer and shallower than that of other parts of Cuba and are used largely for cattle ranching. The mild, semi-tropical climate allows animals to graze in the open throughout the year, and very little grain, hay, or any other kind of feed other than pasture is given to stock, although herbage tends to run short in the dry winter season. The commonest grass of the lowland savannahs is Pará grass (*Panicum purpurascens*), but Guinea grass (*P. maximum*) is also widely distributed. (Minnemann, 1942.)

Carabia writes that these two grasses are cultivated. He notes, as common in the savannahs with the best soils, grasses of the genera *Panicum*, *Paspalum*, *Arundinella* and *Arthrostylidium*. (Carabia, 1945.) Roig y Mesa and Acuña, who state that Cuba has over 13 million acres (5,200,000 hectares) in pastures to support its live stock, mention in addition the native grasses *Paspalum plicatulum* and *P. notatum* together with three introduced species of *Andropogon*, *A. annulatus*, *A. pertusus* and *A. caricosus*. The tops of sugar cane are also used for feeding oxen in the sugar cane districts. (Roig y Mesa and Acuña, 1945.)

Certainly effective use is made of the Cuban savannahs. During the last fifteen years remarkable developments have taken place, with Government aid, that have transformed the country from a heavy importer of meat and dairy products to a position of self-sufficiency and even to an exporter of these commodities. At the same time meat consumption in Cuba is low, and the productivity of the live stock is low. Cattle breeds are mixed, consisting principally of the old colonial stock crossed with Zebu, and some other improved stock (Shorthorn, Hereford etc.) has also been introduced. The native-Zebu animal, however, is most adaptable to the subtropical climate and to existing solely on savannah herbage. (Minnemann, 1942.)

CHAPTER 7

THE TEMPORARY LEY

In the days when the great natural grasslands were scantily occupied, periodic shortages of feed due to seasonal conditions, abnormal droughts or other circumstances were compensated by the enormous range of land available to stock. Animals wandered at will and generally found some means of subsistence, and if their quality suffered in the process, that was no very great matter of concern. With the intensification of the cattle industry in the middle of the nineteenth century, however, accompanied by land fencing and the demand for a higher grade and more rapidly obtained animal product, it was soon found necessary to provide additional feed for periods of scarcity, notably the dry season.

Nor was it only seasonal shortage which made the cultivation of additional fodder necessary. As has been noted by Kok (1943) in the case of São Paulo, Brazil, and by Sordo (1941) in that of Colombia, the South American grazer has at all times to reckon with a deficiency of protein and mineral elements, especially phosphorus and calcium, which is in direct relation to the poverty of the natural herbage in legumes and also to fairly common soil deficiencies. For the better class of stock it became necessary to provide the wanting elements through the cultivation of nutritive plants.

These needs were met by the temporary ley, which in South America is generally grazed. Sometimes, as for dairying in the vicinity of urban centres, it is used as a silage crop. Haymaking and ensilage have been relatively rare until recently and are still seldom seen in the hot regions, but are now more or less common in the pampas of Buenos Aires and the Argentine provinces of Santa Fé, Córdoba etc. (Burkart, 1945*b*), and everywhere in Latin America efforts are being made to increase their popularity.

The need for temporary leys has been greater in some parts than in others. In Chile, for example, the great central region which contains the majority of the country's population is almost entirely dependent upon leys for the feeding of such stock as is not relegated to the Andean hill or valley grazings, because in this region ordinary herbage and the grasses in particular fail for lack of moisture. (Matthei, 1939.)

(a) Lucerne leys

(i) ARGENTINA

In discussing South American leys first reference must be made to the classic lucerne ley of Argentina. It was in this country, the pioneer of intensified stock raising in Latin America, that the need for supplementary feed first became urgent, and the plant chosen for the solution of the problem was lucerne, known generally in America by its original Moorish name, alfalfa. Success was immediate and striking, for in the soils of Argentina, especially those of the west of the province of Buenos Aires and adjacent parts of the territory of La Pampa, *Medicago sativa* found excellent conditions for growth, and from 1890 onwards it has been the characteristic plant of the best Argentine grazings.

Lucerne is not a native of South America. Klinkowski (1933), in a study of its ecology and distribution, has shown that from its original home in north-western Iran it migrated by way of Spain to Mexico, Peru and Chile in the sixteenth century, and thence across the Andes to Argentina. Its cultivation in Peru and Chile is of greater antiquity than in Argentina, but in the last-named country its area has assumed such enormous proportions and achieved such fame that the Argentine leys are here considered first.

AREA

The lucerne area in 1872 was 20,000 hectares, in 1895 it was 516,000 hectares, and in 1918 it reached a peak at 8,703,270 hectares. Although since that date there has been a steady decline in the lucerne area, which from 1929 onwards has not exceeded an approximate five and a half million hectares, yet Argentina's acreage continues larger than that of any other country, the only one which at all approaches it being in the United States of America. (Boerger, 1943.)

LONGEVITY

The longevity of the lucerne areas has also declined within recent years. Arena (1938) writes : " The Argentine lucerne leys, which used to be famous for their longevity (ten to fifteen years) are not productive for more than five or six years at the present day ", and Davies (1940) reports that they have an average life of about five years. " Sometimes these leys will be down to grass for ten or more years, and still contain small amounts of lucerne, but that is exceptional unless they have been very carefully treated and have not been grazed in every year." Boerger, however, points out that the duration of the Argentine lucerne leys varies considerably with locality. (Boerger, 1943.) He confirms the figure of five to six years for the leys of the pampa, the principal lucerne area, and quotes also the following figures taken from the results of a regional enquiry made by the Argentine Ministry of Agriculture in 1925 :

	Duration of lucerne leys in years			
Provinces of Entre Ríos and Corrientes	...	...	...	3 to 4
Province of San Juan (in general)	...	...	...	15 to 20
Department of Iglesia	...	...	...	50
Department of Jáchal	...	...	...	" from time immemorial and still vigorous "
Province of Santiago del Estero (in general)	...	...	...	3
Department of La Banda		...	...	2 to 3 (formerly 10)

Local differences of this nature are attributable to climatic and edaphic differences, but the declining longevity and productivity evident in long-established lucerne cultures of many parts of Argentina are variously attributed to irrational use, climatic and soil factors, diseases and pests (Marchionatto and Bazzi, 1926, quoted by Boerger, 1943), the use of unsuitable seed (W. v. Petery, quoted by Boerger, 1943), a depletion of subsoil moisture (Nyhus, 1940), deterioration of the land through arable cropping without replenishing plant foods (Davies, 1940), and other causes.

It is possible that through an increasing diversification of farming, seed selection and the control of disease the problem of declining productivity could be solved. Nieves (1938) considers the reduction of the lucerne area unfortunate in view of the fact that only 9 of a potential 37.6 per cent of Argentina's total area is under cultivation. And it was indeed the lucerne ley which put Argentina so much in front of the remainder of the world as a meat exporter and which continues to fatten the best of the Argentine cattle. (Spafford, 1936. Parodi, 1942*d*.)

ADAPTABILITY

An account of the method of growing lucerne in the principal, pampa region has already been given (pp. 21-2). Klinkowski notes that in Argentina an excellent example is afforded of the great ecological range of variation possessed by lucerne. It appears worthy of mention that it has settled in large areas consisting entirely of shifting sand. Under Argentine conditions a process of selection has taken place which has produced a peculiar type, adapted to grazing without

forfeiting its vitality and quite different from the central European lucerne. The same author also describes the production of Argentine lucerne seed, which is said to be popular on account of its good germination capacity. (Klinkowski, 1933.)

CULTURAL TECHNIQUE AND SEED PRODUCTION

Through the kindness of the Director of the Darwinion Institute of Botany, San Isidro, Argentina, who has been studying the theoretical and practical aspects of this culture for many years, the following recent account of lucerne growing in Argentina has been received.

"In the western, irrigated part of Argentina lucerne is as fundamental a culture as in Chile, because of the lack of natural pastures. In Salta, a large province in the north-west of Argentina, two areas exist: the valleys of the river Calchaqui, where seed is the principal harvest, and the pre-Andean plains, where large lucerne fields are grown under irrigation for grazing cattle, both young cattle, fattening cattle and dairy cows. In these intensively grazed lucerne fields seed-setting is poor because of the atmospheric humidity, and seed is bought from the valleys for sowing. In this region the culture is probably as ancient as the Spanish colonization.

"The system of grazing is very interesting because it is believed to be an anticipation of the so-called 'Hohenheim system'; it is intermittent, very intense, and is done at two different periods. To explain this: the animals are not always admitted to the lucerne field, as is done in the pampas of Buenos Aires, but the culture is allowed to grow unmolested until it is beginning to flower, when a large number of animals—up to 18 to 20 steers per hectare—are turned in together so that they graze the great mass of the herbage in a few days, and then they are transferred to another field. In this manner rotational grazing is practised. The grazing of the different fields is done at two different times, namely, 'flowering lucerne' and 'finishing lucerne' is grazed. The former is grazed by animals that are to be fattened, which require the best herbage without stint; and when they have eaten all the best shoots, they are turned out and are followed by young and breeding animals and draught animals, who get the remains of the coarsest shoots with the fewest leaves. The duty of the followers is to do the final cropping ("talar", a term used also for the felling of trees in a wood, is the word employed); that is to say, they eat all the rest right down to the ground without leaving any stems. The growers of this region maintain that if the lucerne is not cut or grazed back to the root, it will not sprout again with energy and will become debilitated. After this double grazing, the culture is irrigated and remains once more free of cattle to grow vigorously. In this manner there are generally taken four or five "crops" of the lucerne per year; each period of this kind of grazing lasts for ten to fourteen days and is almost equivalent to a cut. When a field is let for grazing, six pesos of Argentine currency are paid for each animal per month for grazing the 'flower lucerne', and only two pesos for the same grazing when it is for cropping the remaining stems and leaves. Treated in this manner the lucerne cultures last for four to six years. There is little haymaking here because the rainy climate in summer makes the operation very difficult.

"The enormous lucerne area of Argentina may be divided into two large sections; the irrigated area of the west and the unirrigated cultures of the east. In the west the provinces of Salta, Santiago del Estero, Mendoza, and the Government of Rio Negro are the great centres of the irrigated cultures. In San Rafael, in the middle of the province of Mendoza, there are large lucerne cultures where modern mechanized methods of cultivation are employed; the same is true of the valley of the Rio Negro—famous for its good vines and fruits, but the lucerne cultures occupy an even larger area than the others. This region specializes in the making and baling of lucerne hay. The commonest size of bale is a small one of approximately 40 kg. In this form lucerne hay is sold to stock raisers in the west of Buenos Aires during periods of drought.

"The production of lucerne seed is abundant and easy in all the western irrigated zone and also in the western unirrigated part, but in eastern Argentina the humidity and rainfall make seed production very difficult and uneconomic. In the trade, lucerne seed from the dry farming zone is esteemed more highly and fetches a higher price than that of the irrigated zone. This is due to the fact that it contains fewer hard seeds and, perhaps, that it comes from populations more adapted to resist the frequent droughts than is the irrigated lucerne. For this reason, therefore, there is fairly frequent adulteration of seed from the dry region with seed from the irrigated zone. Seed harvesting is done by primitive hand or mowing machine methods on the small farms of the west (for example, La Rioja), or by more up-to-date machines on the mechanized farms in the west of Buenos Aires. In general *local* lucerne seed is preferred for sowing as being better adapted. In many trials Argentine seed has proved superior to European or the North American (even the bred strains) for cultivation in Argentina. A serious pest in seed cultures of lucerne is a species of the Lepidoptera, *Colias lesbia*, called 'isoca' in the east of Argentina and 'cuncuna' in the west, a butterfly, the larva of which eats all the aerial parts of the lucerne and, as it appears in great numbers, causes much destruction. Locusts (species of the genus *Trigonophimus* and others) also do much damage to lucerne, especially in Buenos Aires.

"A very important centre for the production of lucerne seed of the non-irrigated zone, famous in the seed trade, is the district of Villarino, in the south of the province of Buenos Aires, south of Bahía Blanca. The agricultural colonists of that district live principally from the harvesting and sale of lucerne seed. Harvesting and threshing is done mechanically, with machines similar to those used in great wheat areas, but adapted to the fine seed of lucerne. It is said that seed crops of as much as 900 kg. per hectare are obtained there. The climate is arid (rainfall approximately 450-500 mm. per year) and the success of the culture appears to depend in many cases on whether (unless there is irrigation) there is an infiltration of subterranean water into the soil within reach of the lucerne and derived from the neighbouring river Colorado." (Burkart, 1945*b*.)

Argentine research workers are giving careful consideration to the plant which constitutes a source of national prosperity.

BREEDING

Genetical studies and breeding have been carried out by Burkart from 1931 onwards. In 1933 an article on the floral biology of lucerne was published by this author in collaboration with Ragonese.

The following insects were observed to produce tripping of the flowers: *Xilocopa splendidula* Lep., a large insect which is not very abundant, but one alone can pollinate many flowers; *Scolia mutanda* Burm., a humble bee over 2 cm. long and very effective in tripping, but likewise not abundant; a species of *Megachile*, a small and very active bee and possibly the most effective local agent of tripping. It produces tripping by introducing its head between the standard and the keel, while in the case of *Xilocopa* and *Scolia* the flower is tripped more or less by the weight of the insect adhering to the keel or alae. A beetle, *Euphoria lurida* Fabr., trips the lucerne flower by climbing up the raceme, but it is only occasionally seen. It is probable that this list will be augmented as a result of further study. Humming birds are said to visit lucerne, but this was not observed by the authors. Two of the insects which most frequently visit lucerne flowers, *Apis mellifica* Fabr. and *Colias lesbia* Fabr., are ineffective in producing tripping, and the last-named insect has recently been recorded (Burkart, 1945*b*) as a serious pest of lucerne seed cultures. Automatic tripping through change of temperature, etc., cannot be very frequent, and the supply of natural agents is insufficient.

Fifteen representative plants from old stands were studied for the effect of selfing and cross-fertilization respectively upon seed-setting. Although more flowers (2,952) were selfed than were crossed (1,730), the crossed flowers produced nearly as many fruits (1,567) as the selfed (1,694) and three times as many seeds (10,751 as compared with 3,575). The number of seeds per flower averaged 1.21 in the selfed and 6.21 in the crossed.

Pod size and with it the number of spirals were augmented in the crosses; the following approximate figures being given:

Self-fertilization: 1.4 to 2.6 spirals, or an average of 1.96 spirals per pod.

Cross-fertilization: 2.4 to 4.3 spirals, or an average of 3.33 spirals per pod.

Allowing for varying degrees of self-fertility and the small amount of material, it is probable that the more frequent cross-fertilization is, the heavier will be the seed crop, other conditions being equal. (Burkart and Ragonese, 1933.)

From 1931 to 1937 Burkart worked on local lucerne strains, selecting for resistance to *Anguillulina dipsaci*. This nematode is a serious parasite of lucerne in the moist region of cultivation, in the strip of land between Santa Fé and La Plata, and in irrigation lands of the interior (Salta, San Luis, Mendoza). It is capable of destroying a lucerne culture in a short time. Selection for immunity is considered to be the best control. This, carried out by means of artificial infection tests, was entirely successful, among 500 plants 40 resistant were found, but the plants were heterozygotes. Resistance or immunity is dominant and governed by more than one Mendelian factor; plants susceptible to the nematode gave, when selfed, purely susceptible progeny. (Burkart, 1937e, 1943b.) The selected plants were passed on to the Experiment Institute at Santa Fé, where a distinct, resistant variety has been produced through continued selection by Ragonese. This variety is now in course of multiplication and will shortly be put on the market in the affected regions. (Burkart, 1945b.) Ragonese and Marcó studied a large number of Argentine and foreign varieties for their resistance to the nematode. Their material included Provence among the foreign strains and, among Argentine strains, the F₁ generation of selfed resistant or immune plants. The greater degree of resistance or immunity exhibited in Santa Fé by the majority of the foreign lucernes is supposed to be attributable to a process of natural selection, but their productivity, in the absence of the nematode, is inferior to that of the indigenous lucernes. The study of the progeny of selected material confirmed Burkart's finding on the value of selection for obtaining resistant types. (Ragonese and Marcó, 1943.)

An article on the frequency of cross-fertilization in lucerne was published by Burkart in 1937. Plants with entirely white flowers arose through segregation in a self-fertilized line of ordinary violet-flowering lucerne in 1933. Experiments in the selfing and crossing of these plants showed that the character "white-flowering" is completely recessive, and is probably governed by the independent but similar action of three factors.

White-flowering lucerne is good material for determining the degree of cross-fertilization. The author sowed down seeds which had formed spontaneously from white-flowering individuals completely surrounded by violet-flowering plants, and determined the ratio of white-flowering to violet-flowering in the descendants. As every violet-flowered or variegated individual in the progeny must have arisen through spontaneous crossing, the number of these gave a direct measure of the frequency of xenogamy. The results show that on an average 84.54 per cent of the seeds are formed through cross-pollination, but that in individuals this number varies greatly (67.02 to 98.49 per cent). It is recommended that white-flowering lucerne be employed for experiments of this nature in various districts in order to determine what differences exist in the frequency of cross-fertilization. White-flowering lucerne can also be utilized in determining the minimum distance requisite for the effective spatial isolation of different lucerne strains in seed production. A negative correlation appears to exist between frequency of cross-fertilization and degree of self-fertility.

The importance of the old, regional strains for lucerne breeding and the value of selection within old stands is emphasized. As a special problem selection for immunity to certain causal agents of disease is discussed. Finally, a plan for the practical utilization of heterosis is outlined. For this purpose it is necessary to determine as favourable combinations as possible of approximately homozygous and self-sterile plants. Once in possession of such parent plants it is considered that the matter would be easy. Clones of both plants, obtained by vegetative reproduction, would be planted out, whereby the one and the other parent plant would stand in alternate rows. Both parents being self-sterile or nearly so, practically all the seed formed would be characterized by the hybrid vigour of the F₁ generation, in so far as due care had been taken to ensure the spatial isolation of the field. It would be possible to obtain this F₁ generation afresh by renewal of the clones at stated intervals. (Burkart, 1937d.)

GROWTH HABIT

Winter growth habit in over fifty types of lucerne, of both Argentine and foreign origin, has been studied at the Juan Lapacette Forage Plant Experiment Station in the Province of Córdoba by Hoess (1941).

Three groups are distinguished in accordance with their winter growth habit, as follows: (1) Varieties from North America, namely, Ladak, Kaw, Hardigan, Hardistan, Grimm and Variegated. The winter growth is

slow, almost stationary, the plant remaining at ground level until the spring. Yield in these varieties is the lowest obtained under the local conditions of the Station. (2) Varieties from the Argentine province of Santiago del Estero (Saladina and Inverniza No. 3), the Peruvian varieties Peruana and Peruana Glabra, and the French variety Provence. In these there is prolonged winter growth, giving as a rule one extra cut, growth continuing afterwards as long as there are no heavy frosts, to which these varieties are very sensitive. The yields obtained range from medium to good. (3) Varieties emanating from the irrigated and dry-farming zones of the rest of Argentina. These are of intermediate winter growth, wherein there is no difference between the irrigated and dry-farming varieties, although in yield the latter are superior. To group 3 belong also new strains selected, from plants of ten years and older, for resistance to frost and disease. The yield obtainable from the last-named is superior to that of all the varieties tested.

To this account Hoess adds observations on the effect of heat (a lamp, focussed sun rays) in producing the explosion of the flower in *Medicago sativa* and on the possibility of obtaining increased seed-setting by means of applying carefully graded heat. The effects on seed-setting of isolation cages (unfavourable shading), of manipulation, of wind, rainfall, etc., are also briefly discussed. (Hoess, 1941.)

CHEMICAL COMPOSITION

Dankert (1942) has recently reviewed work on the chemical composition of green lucerne as affected by (a) cutting, (b) stage of growth, (c) proportion of leaf and stem, and (d) the hour at which the crop is cut, and the chemical composition of lucerne hay as affected by different methods of hay-making. He reviews in addition the literature on the vitamin content of lucerne, as follows :—

Vitamin A and carotene (quantitative determination of carotene, carotene content of green lucerne and of lucerne hay respectively) ; vitamin B1 and B2 (or G), vitamins C, D, E, K and U, and a growth factor determined in lucerne meal by Jukes and Babcock (*J. Biol. Chem.* 125. 169. 1938).

Schiell and Ragonese have studied inoculation in Santa Fé, and consider the practice desirable in that region (1942).

The popular agricultural press and the publications of the Ministry of Agriculture, including its Yearbook, include much helpful matter on lucerne for the Argentine lucerne grower.

(ii) URUGUAY AND BRAZIL

In view of the spectacular success of the lucerne ley in Argentina, it has been natural for other countries similarly engaged in cattle raising and similarly faced with a periodic shortage of fodder to turn to the same solution of the problem as Argentina. But in Uruguay and Brazil it has not been found possible to establish lucerne grazings like those of the pampa, although success might have appeared probable. The lucerne area of Brazil is 25,650 hectares and that of Uruguay 4,346 hectares only, compared with 5,554,685 hectares in Argentina. (1935/36 figures. Boerger, 1943.) In the case of Uruguay, the difference between the ease with which the vast lucerne cultures of the Argentine province of Buenos Aires are grown and the difficulty with which the same plant is established in practically the same latitudes in Uruguay, in land separated only by the waters of the Rio Plata, is very striking. The obstacle in Uruguay is considered to consist not in the more maritime climate (since lucerne has flourished for centuries in the plains of Chile and Peru close to the Pacific Ocean), but in the nature of the soils, which in Uruguay are for the most part compact, with impermeable subsoil, and have a slightly acid or acid reaction. (Boerger, 1939*b*, 1943.)

URUGUAY

Klinkowski writes that in spite of the difficulties there are many farms which grow lucerne successfully, owing principally to the peculiar use made of lucerne : in the vicinity of the city of Montevideo, in particular, it is retailed in quite small bundles. The district where it is produced (Rincón del Cerro) is situated on the border of the Departments of Montevideo and Canelones. The method of farming employed here is described by Boerger as follows : " For the growing of lucerne those deep rich soils in the neighbourhood of the capital, Montevideo, and particularly in the Department of Canelones, are sought and are prepared by the most careful tillage and

manuring. Stable manure plays an important part in this preparation. Farmers often bring manure from the corrals of the great slaughter-houses and from the central collecting ground for cattle near Montevideo, and it is applied in doses of between 16 and 24 tons per acre. But in addition to this (especially recently, in consequence of modern manuring propaganda and improved transport facilities) it had become more and more customary to use the local phosphatic manures, available in the form of bone ash and bone guano from the same slaughter-houses. Altogether it is a form of lucerne cultivation very different from that which is conducted over extensive areas in Argentina with ease and without any manuring." (Klinkowski, 1933. Boerger, 1921.)

Constant experimentation is in progress at the "La Estanzuela" Experiment Station. Of pasture types, the Argentine lucernes have proved most suitable for Uruguayan conditions, but hay types are also under observation, and some fine-stemmed hay types are considered promising and seeds from the best individuals have been collected for further selective breeding. (Henry, 1936.) At the present time the New Zealand variety referred to as *Medicago tivacata*,* a new hybrid, is under trial and has already given very interesting results, but it is yet too early for the Station to give a definite report on this plant. (Boerger, 1943.) Spangenberg has studied lucerne varieties in different soils and with different manurial treatment in the hope of encouraging dairy farmers to grow this crop more widely for home consumption, and manurial trials have been conducted by Aznarez. (G. E. Spangenberg, 1937. Aznarez, 1939.) The University of Montevideo has made a special study of Peruvian lucerne, *Medicago sativa* var. *peruviana*, which it is breeding with special reference to Uruguayan conditions. (Rev. Fac. Agron. Montevideo, 1937.)

BRAZIL

Klinkowski reports that in Brazil the lucerne area was originally small, and situated in the south. "Now the crop has become more important, especially in the subtropical zone. In contrast to the suitable districts, where the temperature varies from 11 to 35° C. during the growth period, there are found the less suitable districts of the granite region, where the temperature for the same period fluctuates from 5 to 37° C. The number of cuts which can be obtained is in consequence very variable. The amount of yield obtainable is governed by rainfall and facilities for irrigation. The average rainfall in the good districts varies from 1,400 to 1,550 mm., whereas in the granite region it varies from 750 to 1,750 mm. In the lucerne districts proper the distribution of rainfall is very favourable, whereas in the granite region it is concentrated within a comparatively short period. The amount of rain, in itself considerable, might appear surprising, but the soil absorbs approximately only one-fifth of this quantity. The soils vary from loamy types poor in potash and phosphorus, to those of the granite region where the land is sandy, poor in lime, with pH of 5.5.

"The growing of lucerne here is therefore a difficult matter and possible only after very careful preparation of the ground. Murcia lucerne is the principal type grown, after which Grimm and Provence lucerne also are highly esteemed. On the dry lands, forms of *Medicago sativa* var. *polia* are grown. The slight extension of the lucerne area in the subtropical parts of south and central Brazil when contrasted with its distribution in similar parts of Argentina and Chile may be explained by the question of cost. It requires a greater outlay to sow down new fields here, as for the most part these districts are still covered with forest. Sowing is generally done towards the end of the rainy season, when there is least danger of the heavier soils becoming encrusted. In the arid parts of the country irrigation is of great importance. It is carried out either by running the water in furrows or by flooding, and is continued as a rule from April to September. If the rainy season sets in late, irrigation is carried on into October." (Klinkowski, 1933.)

The authorities endeavour by means of literature to spread information on suitable varieties and cultural and manurial technique. (Brazil, Min. Agric., 1934a. Cuba, 1938.)

* The name *Medicago tivacata* is not valid, but is combined of the words *sativa* and *falcata* in order to indicate a hybrid which is approximately equal to *Medicago varia* Martyn or *M. media* Pers. (Burkart, 1945b.)

(iii) PERU AND CHILE

Whereas in Argentina, Uruguay and Brazil lucerne is grown as supplementary fodder, the natural grasslands providing the bulk of animal nutrition, in the central region of Chile, which contains the majority of that country's population, and to a large extent in Peru, it is grown as the staple fodder. In Chile grass takes a second place because in the central region grasses fail for lack of moisture, and in Peru there is a great lack of natural pastures excepting in the highest regions, which are almost entirely uninhabited.

The areas devoted to lucerne in these two countries in 1929-30 were 94,738 hectares for Chile, and for Peru 142,792 hectares, although in the case of Peru the figure is approximate only, since other forage plants are included in the count. (Boerger, 1943.)

PERU

In Klinkowski's report it is stated that for Peru lucerne has become absolutely indispensable. The most suitable localities for its cultivation are those situated between 1,000 and 3,000 metres above sea level, the upper limit is 3,600 metres. "Very moist and very warm districts are unsuitable for lucerne. It is grown on different soil types. The seed used is mostly home-produced. As a rule the crop is used fresh, although it is carried in the form of hay into a few districts which are poor in natural fodder. The Peruvian lucerne has grown for many decades in an equatorial region where annual variations of temperature are comparatively small. The temperatures in summer are not as a rule very high nor are the winters very cold. Peruvian lucerne, of which there is one smooth and one hairy variety, is easily distinguished by the structure of its leaves, which are three to five times as long as they are wide. Physiologically it is distinguished by poor winter hardiness. In every district where the temperature falls below a certain point during the winter months, Peruvian lucerne dies before any other variety. It may seem paradoxical that slight frosts do not even temporarily hinder the growth of Peruvian lucerne, which is also true of Arabian lucerne. In districts with mild winters the growth of winter hardy varieties ceases almost completely, whilst those varieties which are particularly susceptible to cold grow continuously, so that the first cut of Peruvian and Arabian lucerne can be taken as early as the end of February. This may be explained by the fact that these forms continue to grow in temperatures in which winter hardy varieties still remain dormant.

"Peruvian lucerne has in suitable localities numerous advantages, such as a far more vigorous growth and more rapid tillering after cutting. Under favourable climatic circumstances it can grow the whole winter through, and thus can produce one or two more hay cuts per year. Its disadvantages are its hairiness, at least in the case of one variety, and its tendency to lignification; these disadvantages may be obviated to a certain extent by thicker sowings. Lack of winter hardiness will always confine Peruvian lucerne to certain areas, and its tendency to become woody makes it unsuitable for large districts (arid regions) which can produce good crops only with thin sowing.

"Under the climatic conditions which are favourable for the growth of Peruvian lucerne, the flowers are easily pollinated and give an abundance of seed. Cool weather encourages seed-setting far more than decidedly high temperatures. The well-known "San Pedrana" variety comes from the coastal region in the vicinity of San Pedro near Pascamaya, being grown preferably on loose sandy soil with a moist subsoil. It has an average duration of four years only; it is distinguished by high yields and can be cut the whole year round about every six weeks, as compared with only six cuts of the ordinary variety ('native lucerne'). Seed from the neighbourhood of Supe is particularly highly esteemed in the coastal lands of Peru, while another variety, very similar to the smooth Peruvian lucerne, is said to be grown in very high localities near Kandarava. Peruvian lucerne has become important in the south of the United States, where it is found at the present time in Arizona and California under the names of 'Hairy Peruvian' and 'Smooth Peruvian'. It is grown to a smaller extent in New Mexico, Texas and the coastal regions of the south-eastern States." (Klinkowski, 1933.)

CHILE

In Chile lucerne is equally indispensable. According to Matthei (1939) its area increases every year, and Opazo writes that it could not be replaced by any other plant, for it produces at the same time the maximum amount of forage and the most nutritive feeding-stuff. It grows well from Arica (18° 32' S.) as far as the river Maule (35° 40' S.), but farther south—as far as the river Bío Bío (37° 45' S.)—it is more difficult to grow, and in this sector climatic conditions are

more favourable for clover. The introduction of varieties resistant to frost and to wet soils would, however, enable the Chilean lucerne area to be greatly increased. Seed is grown under irrigation and is concentrated principally in three provinces, the same provinces having also the highest lucerne acreage. The average quantity of lucerne harvested is 20 to 30 thousand kg. green weight or 6 to 7 thousand kg. dry weight per hectare. (Opazo, 1939.) Matthei records that stock raising in the central zone is based mainly on lucerne, which, together with wheat, is becoming the most important plant in Chilean agriculture. This author writes that a lucerne culture will last for ten to fifteen years without renovation and with little loss of vigour, but it is customary to use it for grazing or haymaking for a maximum of eight to ten years. Three or four annual hay cuts can be obtained, and the baling of hay, for home consumption or for sale, is common. Haymaking is greatly facilitated by the almost entire absence of rainfall in summer. A common rotation in the irrigated lands of central Chile is an alternation of cereals, grown once or twice, with forage plants, generally lucerne, grown for about seven years and subsistence peasant crops grown for half a year. (Matthei, 1939.) The varieties most suitable for Chile are the indigenous, adapted varieties Huasco (considered the best) and San José de Maipo, but other varieties are also grown. The best indigenous seed is grown in the mountain regions. It is usual to graze lucerne leys or to cut them for hay, but Opazo, who gives full directions for optimal lucerne cultivation, both under irrigation and dry, considers the trampling of lucerne by cattle a wasteful procedure and recommends rather its employment as a soiling crop, cut and fed green to stock. He considers also that the Hohenheim or rotational grazing system might well be applied to lucerne leys. (Opazo, 1939.)

(iv) OTHER LATIN AMERICAN COUNTRIES

Pittier reports that in Venezuela attempts to grow lucerne have been unsuccessful. (Pittier, 1939.) Klinkowski gives information of lucerne cultivation in some other countries. In Paraguay the crop is practically of no importance: it deteriorates rapidly except in the virgin soil of forest clearings, but the labour and cost of growing it under these circumstances are prohibitive. For Ecuador and Guatemala Klinkowski gives the following information:

"The lucerne ordinarily grown in the highlands of Ecuador is generally found in very light, loose and sandy soil. A well-known variety is the 'Guaranda' lucerne, which derives its name from the capital of the Province of Bolova; its cultivation is more concentrated in the neighbourhood of this town, which is situated at a height of 2,100 metres. Guaranda lucerne resembles Peruvian lucerne. My information on the growing of lucerne on the higher plateaux of the Andes is based on data given by Luis Sodizo. The estate of Velasco in the neighbourhood of the town of Pamasqui is situated at a height of 2,800 metres and has an average temperature of 15–16° C. with slight variations between day and night. The soil is sandy and adequately provided with organic matter. The water supply, although not over-abundant in comparison with the extent of the area cultivated, is adequate for the requirements of vegetation. A well-cared-for field should persist under good conditions for about thirty years. The ordinary lucerne of the Ecuador highlands is sold in Ambata; it is grown for the greater part in the vicinity of the town itself on very light soil. Characteristic of this vicinity is its low precipitation.

"In Guatemala there grows near Antigua a form of lucerne which was probably brought into the country as long ago as the period of the Spanish colonization. It has always proved superior to Grimm lucerne and all the other varieties which have been grown here for purposes of comparison. Lucerne is grown in Antigua without irrigation and flowers even in the driest time of the year, although no rain falls from October until May. The average annual precipitation amounts to 750–1,000 mm. The water table in parts of the Valley of Antigua lies 2 metres deep. The fact that eight or ten cuts can be obtained annually indicates the vigorous growth of this lucerne in spite of the continuous drought." (Klinkowski, 1933.)

Sierra, of the Agricultural College, Guatemala, has conducted trials under temperate, temperate to cold, and cold climatic conditions. An account has been published treating successively the class of land required for lucerne, with special reference to its peculiar rooting system, seed, preparation of the ground, sowing, seeding rate, re-sowing, germination (extremely rapid under the

tropical conditions of Guatemala), growth and cultivation, cutting and yield, conservation, uses (soiling crop or grazing), seed production, and varieties.

Although indigenous seed, being less susceptible to rust, gives better results than foreign seed, the latter is commonly used on account of its greater cheapness (often less than half the price of indigenous) and purity. Under average conditions a Guatemalan lucerne stand lasts for five or six years, although under especially good conditions of fertility and cultivation it may last for nine or ten years. It is commonly used for hay and as a soiling crop cut in the afternoon to be fed the following day, but old stands are used for seed production or for grazing. The first cut may be taken 4.5 to 5 months after sowing, and thereafter the stand may be cut every 40 days. Seed is taken from the second to the fifth cut. Average yield in temperate regions is 12 to 14 tons per hectare, but in some parts of the country reaches an average of 20 tons per hectare. (Sierra, 1945.)

The Guatemalan Government is encouraging the use of this crop. (Asturias, 1940.)

The growing of lucerne in Mexico is considered by Klinkowski particularly interesting from an historical point of view, as it is probably the very first American country in which this plant in the course of its migration settled. It was introduced by Cortés and his followers about 1519, but its modern area, 34,065 hectares (figure for 1935), is not very great. The principal lucerne cultivation zone is that in which cattle raising is most important, the central valley, and here also the lucerne quality and the seed produced are best. Cultivation is generally under irrigation. A Mexican method of sowing seed mixed with sand through the tip of an old cow horn is described by Klinkowski. (Klinkowski, 1933.)

(b) Cereal leys.

The ley composed of cereals, not harvested but grazed when still green, is a characteristic feature of stock feeding in Argentina and Uruguay, where sowings of this nature by far outweigh in numbers and importance sowings of any other cultivated grasses. The four European cereals are those generally used, in the following order of precedence: oats, wheat, rye, barley. Wheat for grazing is, relatively speaking, a newcomer, but is gaining rapidly in popularity. The leys are used for the provision of winter feed and for fattening, and it is customary to obtain a grain crop after the winter's grazing.

Little information on the use of cereal leys in South American countries other than Argentina and Uruguay is available, except that in the frontier region of southern Brazil, close to Uruguay, leys of oats or rye are beginning to appear (Domingues, 1941*b*), and that in Chile, too, cultures of this nature appear to be gaining in favour. Matthei reports that oats are increasingly used as a soilage crop on Chilean dairy farms, and Opazo considers that this is preferable to grazing them, although the latter practice, apparently, is not unknown. In the central region of Chile oats grow readily and give two cuts, and in the southern province of Magallanes their cultivation for hay and for stack silage is increasing. Barley is grown to be fed green to cattle in winter, but Opazo considers it of little nutritive value. Rye, introduced by Swedish and German colonists, finds favourable conditions south of the river Bío Bío and is also grown as a forage crop and fed green to stalled cattle in winter. It is considered by Opazo more nutritive than green barley or oats. No mention is made of grazing it in Chile. (Matthei, 1939. Opazo, 1939.)

In Argentina, in the great pampa region, including the province of Buenos Aires and large parts of the provinces of Santa Fé, Córdoba and Entre Ríos, cereals find optimal conditions of growth. The flat lands composed of deep, fertile loess soils, the temperate climate and the quantity and distribution of the rainfall enable highly productive crops to be obtained without irrigation, without the use of fertilizers, and with a minimum of labour, nearly all mechanized. (Parodi, 1942*d*).

AREAS OF GRAZED CEREALS

In a table presented by Boerger in 1943 there are shown for Argentina the areas of the various cereals sown and harvested respectively. The difference between the sown and the harvested area in each case may be taken, it is said, to represent approximately the area devoted to grazing, although a certain proportion may be attributable to loss through frosts, insect pests, etc. In this manner the following figures are obtained:

				Argentina: area grazed, in thousand hectares, for the years				
				1934-35	1935-36	1936-37	1937-38	1938-39
Oats	...	...	...	573	642	502	601	640
Wheat	...	...	...	671	1,020	678	1,662	715
Barley	...	...	...	182	278	241	331	332

The harvested area of rye is not shown, but the sown area for the years in question amounted, in thousand hectares, to 533, 232, 273, 204, and 433 respectively, and it is probable that most of this was used for fodder purposes. (Boerger, 1943. Vol. 1, Table 18, and Vol. 2.)

According to Parodi (1942), the Argentine areas of fodder oats and rye are now much greater. Approximately one and a half million hectares of oats are grown almost exclusively for fodder, either for winter grazing or for grain. The species generally used is *Avena byzantina*. This species is more resistant to trampling and better adapted to the ecological conditions of the pampa than *A. sativa*, of which but little is grown. Over 1,200,000 hectares of rye are grown for winter fodder, mainly in the dry, sandy, western region of the pampa and in the central pampa. The areas of fodder barley are smaller and are found throughout the cereal region.

Boerger writes that the grazed wheat leys have been increasing more especially in the south-eastern part of the province of Buenos Aires, where they are used for the winter feeding of sheep. Their use has also increased in the more northerly parts of the country. (Boerger, 1943.)

Maize, the indigenous South American cereal, in contrast to the four European cereals, is used as a summer feed, cut and fed green, or as a silage crop, but although the difference between the Argentine sown and harvested maize areas in the years 1934 to 1939 amounted (in thousand hectares) to as much as 1,327, 2,495, 1,730, 3,242 and 1,798, its importance for stock feeding is not actually so great, either in Argentina or Uruguay, as that of the grazed winter fodder cereals.

For Uruguay, the 1937 figure for grazed oat leys is 283,204 hectares. Although this represents a great diminution of the 600,000 hectares recorded in 1930, the difference is partly attributable to the increasing popularity of grazed wheat leys. (Boerger, 1943.)

RESEARCH

The research workers of both countries have displayed interest in the cereal leys, and have conducted varietal trials, studied the possibility of producing more resistant double purpose (grain and fodder) varieties, and tested palatability and nutritive value in different species and varieties.

In Argentina the "La Previsión" Experiment Station, which is situated in the southern part of the province of Buenos Aires, 38° 13' S. and 60° 15' W., and is principally concerned with cereals, has made a special study of fodder cereals and has published in its annual reports data on varietal trials, experiments in the time of sowing, seeding rate, and the effect of grazing.

For this station Schelotto (1942b) reports that oats sown in May gave (average of 7 varieties) 2,002 kg. grain per hectare and also afforded winter grazing, but sown in July and not grazed gave 2,856 kg. grain per hectare; barley (average of 5 varieties) under the same circumstances gave 1,996 and 2,476 kg. grain per hectare. Grazing in winter thus entailed a diminution of the subsequent grain crop. (Schelotto, 1940-42. Boerger, 1943.) The same station breeds cereals, wherein use for grazing is a character kept well in view. In

1937 a seven-year comparison was made of the Station's own bred winter oats, selected from the common yellow oat of the region, with the latter and with a white oat variety. Data concerning yield and grain weight for the seven years were given, and, for the year 1937, the yield obtained under early, medium early and late sowing respectively, and with and without grazing. The superiority of the Station's bred strains was apparent throughout. (*Bol. Chacra Exp. "La Previsión"*, 1938.)

The Argentine Ministry of Agriculture commends the sowing of cereal leys and has published advice in its yearbook on methods of sowing and cultivation.

Oats, rye and fodder barley are recommended, and of these the following varieties: oats, Klein's white "Mar", Klein's white "Victoria", Buck's selected yellow, La Previsión yellow No. 13; barleys, Klein's selected forage Trebi, Massaux' forage, La Previsión brewer's No. 19; ryes, Massaux' forage. At the same time several other varieties are mentioned, including Massaux' "sweet" rye, said to be very palatable to animals, and valuable ryes named Hamburg and Waldstaudem respectively. The last-named is long-lived and is said to give excellent grazing throughout the year, a grain crop being obtainable in the following summer. (Garrós, 1942.)

PALATABILITY

Massaux grazed with sheep 253 plots of rye, barley, wheat and oats grown in pure cultures and studied palatability, recovery after grazing, and grain production. The sheep showed preference for wheat, barley, oats, and rye in the order given, and of the last-named crop the "sweet" variety already mentioned was preferred to ordinary rye, which was not touched until all the other plots had been consumed. (Massaux, 1941; quoted by Boerger, 1943.) Henry confirms the fact that rye is left to the last by the grazing animal, but says that it is not actually repellent. (Henry, 1935.)

PRODUCTIVITY

In Uruguay, tests of productivity of green weight were conducted at La Estanzuela as early as 1916-1918. The material comprised oats, barley and rye, wheat not having yet come to the fore as a forage plant.

The plots were cut successively during the winter and spring (not grazed) and the average yield in green weight for the three years 1916-18 was found to be (in quintals per hectare): oats (not specified whether *Avena sativa* or *A. byzantina*), 310.8; barley (*Hordeum hexastichum*), 299.2; rye (*Secale cereale*), 230.8. Climatic and soil conditions had a significant effect on the yield in green weight in all cases: in 1916 (poor soil and unusually prolonged and intense dry season), the yield in quintals per hectare was: oats, 112.5; barley, 114.6; rye, 87.0. In this year all the seed was broadcast. In 1917, when the sowings were made in fertile, humus soil and weather conditions were optimal, the yield obtained was: oats, 509.5 broadcast and 442.5 drilled; barley, 440.5 broadcast and 474.5 drilled; rye, 390.5 broadcast and 348.0 drilled. On the whole, in spite of climatically conditioned differences, oats were found to be superior to both barley and rye in productivity of green matter. (Boerger, 1928, pp. 185-219.)

Bellini, working at the Paysandú School of Agronomy, conducted trials of various forage plants from 1929-34 which are of interest because they include fodder cereals studied for their value in yielding successive cuts of green weight followed by a grain harvest. The material consisted of the principal Uruguayan wheats together with some French varieties and the Argentine "Lin Calel M.A.", the oats *Avena byzantina* and *A. sativa*, forage and brewer's barleys, and rye. Bellini considers the cereals better than the best of the grasses for providing green fodder, and arranges them in order of productivity as follows: oats, barley, wheat, rye. The optimal time of sowing under Uruguayan conditions is noted for each species, and the production of the different varieties is recorded. No direct grazing experiment was conducted by Bellini, but its desirability was stressed by him. (Bellini, 1934.)

GRAZING TRIALS

Grazing trials were conducted at La Estanzuela in 1935, and are described by Henry in an account of work on fodder cereals at that station in 1933-35.

In 1933-34 trials of different varieties were made by means of taking successive cuts, but in 1935 plots were arranged of a size that allowed grazing by cattle in some cases and sheep in others. Four wheats were tested, Renacimiento, Rieti (a strain bred at La Estanzuela from the original Italian Rieti), Lin Calel and Black Hull. Renacimiento and Rieti were grazed by cattle on the 4th and 12th of June, when 25 and 20 cm. high, giving yields of 3,500 and 6,000 kg. per hectare. They were grazed again on the 20th July and the 20th August respectively, and yielded this time 2,200 and 3,600 kg., while Lin Calel grazed for the first and only time on July 19th in one plot and on the 20th August in the other plot gave yields of 2,270 and 3,800 kg. Black Hull, on account of its poor development, could not be grazed. Determining yields at the time of flowering and adding the previous cuts in order to estimate the potential productivity of green fodder up to this period, the following totals were obtained: Renacimiento, 1 metre high, 16,705 kg.; Rieti, 95 cm. high, 23,746 kg.; Lin Calel, 85 cm. high, 14,120 kg.; Black Hull (single cut), 1.10 metres high, 11,015 kg. Although, in view of the success obtained with them elsewhere, the two last-named varieties would probably give better results in other zones, it is considered that Renacimiento and Rieti will always retain their character of giving more forage and of being more reliable on account of their greater resistance to *Puccinia triticina*.

The oat trials included *Avena sativa* and *A. byzantina*, the former species represented by Estanzuela 64s and Klein's Mar, and the second by Estanzuela pedigree 1095a. While *Avena sativa* is characterized by its earliness, leafiness, narrow leaves, etc., *A. byzantina* is distinguished by its semi-creeping growth habit, and by being apparently less early and giving a very fine and at the same time abundant forage. It also has marked resistance to trampling. The total yields in green weight were very similar, 24,300 kg. per hectare for *Avena sativa* 64s, and 23,885 for *A. byzantina* 1095a. (Henry, 1935.)

In 1934 Fischer and collaborators conducted at La Estanzuela and in various localities of the Departments of San José and Canelones trials of five oat varieties, namely, *Avena sativa*, La Estanzuela varieties 64s and B1d1, and Klein's Mar; and *Avena byzantina*, La Estanzuela 1095a and a common Argentine variety. A tabular account is given of the data recorded, which comprise height, vegetative stage, intensity and type of infection with *Puccinia coronifera*, and yield of green forage.

A statistical examination of the yields of the plots where no grazing took place, and after grazing, brings out very striking features of the *byzantina* oats. They are much more uniform in production than the *sativa* strains tested. The yields of the common oat remained on a low level, but the *byzantina* strain 1095a surpassed the *sativa* oats 64s and B1d1 under all unfavourable conditions. Only in the more fertile plots the relation was equalized, and reversed under the very best conditions. As the density of sowing did not influence the yields, both plots of the same variety could be considered as parallels within the block, with a substantial gain in experimental precision. The yield was subjected to the analysis of variance. The 1095a strain of *A. byzantina* was selected from a native population in 1925 and the continued selection of individuals has taken place. (Fischer, Brofos, Bonjour and Gheorghianov, 1937.)

J. Spangenberg conducted a grazing trial of several cereal varieties with sheep and published results in 1935 showing that for the zone concerned (Department of Colonia) *Avena sativa* is unsuitable for continuous grazing, at all events for sheep. The greatest live weight increase was produced on the leys of Lin Calel wheat, and next in order of value came the grass *Lolium multiflorum* and then the Estanzuela forage barley variety 702a. *Avena byzantina* was not included in this trial. In 1937, however, J. Spangenberg compared *Avena byzantina* (a common variety and not the Estanzuela bred strain) and *Lolium multiflorum* grown in good land in the Department of Soriano and used as winter grazing for two to three-year-old steers. The advantage was on the whole with the ryegrass, which proved slightly cheaper to sow, exhibited higher protein content, produced greater live weight increase, was available for grazing for a longer period (190 days, as compared with 174 days for the oats), and remained in a state of productive vigour for a longer period. (J. Spangenberg, 1935 and 1938.)

At La Estanzuela cattle were grazed from 1938 to 1941 on 12 plots each of 1.75 hectares to compare the respective productivity of oats, wheat, barley, rye, and Italian ryegrass considered as winter pasturage. The soil was of medium fertility, poor in humus, which had been used for many years for cereals, and the development of the cultures was not normally good. Apart from the disastrous winter of 1939, when practically the whole experiment was destroyed by *Toxoptera graminum* Rond., the results obtained in the winters of 1938, 1940 and 1941, in which rainfall was very heavy, showed the superiority of *Avena byzantina* for clay soils of the kind used. The forage wheats took the second place, followed by barley, rye being the least vigorous of the cereals. *Lolium multiflorum* is considered of little value during the winter, but with the first warmth of spring it develops luxuriantly and then excels in comparison with the four winter cereals, which are already exhausted as far as their grazing value is concerned. A fuller report of these experiments is to be published. (Boerger, 1943.)

Nores made a comparison of oats and rape for feeding sheep in 1938, when the National Commission for the Forage Problem distributed to various parts of Uruguay 637 kg. rape seed for experimental purposes. In the trials described, sheep were grazed (a) in rape fields on three estates, and (b) in oat fields on two of the same estates. For yield, quality and economy, and under the ecological conditions of the trial localities, rape proved superior to oats. (Nores, 1939.)

Bentancur studied production of green fodder (by mowing) and protein in six cereal varieties. A single trial, without replications, was sown in uniform soil. Each one of the six plots was treated in five different ways, ranging from one single cut to five successive mowings. The experiment does not bear directly on grazing practice, haymaking or ensilage, but the 141 tabulated determinations suggest some practical consequences. The oat variety B1d had a quick start but was severely damaged by repeated cutting, and therefore seems to be unfit under continued grazing. The oat 1095a (*Avena byzantina*) resisted several mowings, being, with the one exception of Black Hull wheat, the poorest yielder of green forage and protein in this trial. Four-rowed barley 702a excelled in amount and uniformity of herbage and protein production. The rye variety Massaux and the wheats Rieti and Black Hull, with a growth habit more adapted to grazing purposes, did well under repeated mowing. Of this group, Rieti gave the highest and Black Hull the lowest yields, the latter showing a somewhat higher protein ratio. (Bentancur, 1940-41.)

Tagle, of the University of Buenos Aires, has shown the value of the cereal ley for fattening animals in the less valuable Argentine grazings, hitherto used almost exclusively for rearing store animals which are transferred at the age of approximately one year to the better, fattening regions. In the south-eastern part of the province of Buenos Aires sixty 6 to 8-month-old Shorthorn steers were wintered and finished for the chilling factory within a period of 7 months and 13 days on sown leys of oats (species not stated) and Sudan grass. The oats pasture was used from September until the 5th January and was stocked at the rate of 2 animals per hectare; on transferring to the Sudan grass pasture for summer grazing an average weight of 320 kg. per head was estimated. The cattle were again transferred on 15th April from the Sudan grass to an eighty-hectare field of oats, in which they were finished by August 18th. The experiment was economically successful, and the cattle were classified as "100 per cent chilled superior" and fetched the maximum price. (Tagle, 1942.)

Dellazoppa, in a "Manual of agriculture" (1939), has published information for the Uruguayan farmer on the growing of oat leys for grazing. (Dellazoppa, 1940.)

THE CEREAL LEY AND SOIL FERTILITY

In an address to the Faculty of Agronomy of the University of Buenos Aires, Ito, formerly Professor of Agronomy in the Moarioka Agricultural College, Japan, and now the owner of an Argentine estate, throws some light on the cereal ley as it affects soil fertility. The growing of cereals in the province of Buenos Aires is remunerative, and for some years Ito had experimented with three rotations with a view to uniting the cultivation of cereals with the conservation of soil fertility on the basis of animal manure. One of the rotations, which is called "forced wheat growing", runs as follows: 1st year, Sudan grass; 2nd year, wheat; 3rd year, oats for grazing and Sudan grass for grazing in the same year; 4th year, wheat; and it continues with the alternation of wheat and oats-Sudan grass every two years. This rotation is used in the most fertile lands of the estate in order to profit by high wheat prices, and it is claimed that the soil is not impoverished because abundant manure is supplied between the two wheat harvests through the heavy stocking of the grazed oats and Sudan grass. In addition weeds are controlled and the ground is left in good physical condition for wheat. Another of Ito's cropping systems includes lucerne as well as barley and oats for grazing; and a third includes oats for grazing and a subsequent grain crop, after which the area is allowed to revert to grass for five or six years, as long as good grasses grow. Ito notes, however, that the rotation containing lucerne has "the very important advantage of supplying a greater quantity of protein to stock and at the same time of accumulating surface humus containing a greater quantity of nitrogen. Nor can one overlook the service

rendered by the deep roots of the lucerne, which obtain ash substances from the subsoil and accumulate them in the cultivable layer of the ground." (Ito, 1939.)

Although Ito on certain parts of his estate appears to grow the cereal ley in land actually suitable for lucerne, relying solely upon the manure supplied by the grazing animal for the maintenance of soil fertility, it should be noted that as a general rule the cereals are grown primarily in lands unsuitable for lucerne or else to supplement existing lucerne cultures in winter, when the growth of the latter is slow. (Boerger, 1943. Vol. 2. p. 886.)

Toxoptera graminum Rondani, the green fly of cereals, has become a source of serious damage to forage cereal crops both in Argentina and Uruguay, and in both countries means of control and specific and varietal differences of resistance in the various cereals are under investigation. (Hayward, 1940. Boerger, 1943.)

(c) *Trifolium*

In view of the success that has crowned the growing of lucerne, an introduced plant, and of the felt need in South America for a better supply of proteins, it appears perhaps surprising that the *Trifolium* species, also introduced, should not have gained a firmer foothold in the continent.

TRIFOLIUM REPENS

T. repens appears to be the most widely disseminated. Burkart reports it to be the commonest clover species in Argentina, where it is sown for artificial leys to be grazed and is spreading by natural means. Recently in some parts of north-western Buenos Aires province a white clover seed production industry has become established because of the high prices obtainable. When the weather is dry in November and the following months of summer, the clover no longer grows but flowers and fruits in abundance. It is harvested with a lucerne mowing machine, fitted with a narrow platform to collect and pile up the cut crop. It is allowed to dry and is threshed with an ordinary thresher, but the straw is passed through two or three times because it is difficult to extract all the very fine seed.

By some riversides (Río Negro, Río de la Plata) *T. repens* f. *riparia* forms close swards which seldom flower. Davies writes that white clover grows almost like an indigenous plant in the grasslands of the Andean foothills from the territory of Neuquen to Punta Arenas in the south, and in other places visited by him. It is uncommon in Uruguay and in trials at La Estanzuela proved practically a failure. In Chile, however, it is found in abundance, having become naturalized and being readily propagated especially in the south and in cool, moist lands generally, and seed is being reproduced for distribution by the Government. The white clover commonly found in the Argentine pampa is said by Burkart to be more or less unpalatable to the cattle of that region, which do not graze it if grasses are available. He considers this attributable to the fact that most of the white clover naturalized in Argentina belongs to the hardy *T. repens* var. *sylvestre*, which is almost invariably cyanophoric. The warm Argentine climate and heavy trampling by cattle may possibly produce increased cyanogenic glucoside content. Trial for adaptation in Argentina of cultivated races such as *T. repens* var. *giganteum*, which is non-cyanophoric, are considered desirable. In Colombia white clover grows wild in fertile spots, such as the sleeping-places of cattle, in the cold lands (6,500 feet or 2,000 m. and upwards). It is described as the best legume for grazings in these lands. The average annual yield obtained at the Experiment Station of La Picota is 18,500 kg. green weight. It is recommended by Argüello for use in the high lands of Guatemala. (Burkart, 1943, 1945. Davies, 1940. Boerger, 1943, Vol. 3. Opazo, 1939, Vol. 3. Abadia, 1943. Elgueta, 1944. Argüello, 1938.)

TRIFOLIUM PRATENSE IN ARGENTINA AND URUGUAY

Trifolium pratense is little used in Argentina and Uruguay. In the last-named country trials at La Estanzuela have hitherto had negative results, but now a small quantity of seed has

been harvested from an imported New Zealand strain and it is possible that from this material a form may be produced which is adapted to Uruguayan conditions and suitable for sowing in mixtures with forage oats or other cereals. In Argentina, according to Burkart, red clover is cultivated in limited areas of Andean Patagonia and in Tierra del Fuego, in both of which regions it will become increasingly important. Excellent cultures were seen by this author in the western part of Nahuel Huapi. It grows well also in the Paraná delta. Davies, writing of the Andes foothills, says there is no reason why red clover, together with some other European grassland plants, should not thrive over considerable areas in the Andean valleys. The same author, referring to an animal breeding station in the foothills of the high Andes of north-western Chubut, considers that there also red clover, together with white clover, trefoil and lucerne, could probably be established without irrigation. (Boerger, 1943. Burkart, 1943. Davies, 1940.)

TRIFOLIUM PRATENSE IN CHILE

In central and southern Chile, *Trifolium pratense* is already firmly rooted. It is cultivated in the valleys of Valdivia and Cautin (38° to 40° S.) in leys having a mixture of *Phleum pratense*. In the centre of Chile it has been used as a green manure in sandy lands and has transformed them within a short time into profitable wheat and potato lands. It is customary also to sow red clover in a mixture with wheat in May or June; the wheat is harvested in December, leaving the red clover to furnish forage in February or March. (Burkart, 1943.) Red clover was introduced into Chile from England in 1877 and was immediately successful. One of its early protagonists described it as likely to bring about a revolution in Chilean cropping systems, and this actually occurred, for the earlier introduced lucerne in due course gave place to red clover. (Vergara, 1938.) That this position has been maintained is seen by figures for the 1929-30 areas (in hectares) of lucerne and red clover respectively, namely, 96, 684 and 99, 493. (Opazo, 1939. Vol. 3. pp. 48 and 96.)

Nevertheless red clover does not yet occupy the place it might well take in the agriculture of southern Chile. Such, at least, is the opinion of Matthei (1939, p. 65), Opazo (1939) and Vergara (1938). Opazo writes that "from the river Maule southwards this plant should take the foremost position as a forage plant in the irrigated lands, except for those restricted areas in which it is possible to grow lucerne. For the lands south of the Maule red clover should be what lucerne is for the lands north of that river". Vergara writes that "in the south of Chile, our most extensive agricultural zone, lucerne does not thrive but clover [red clover], which requires less warmth, grows very well". He recalls seeing on hillsides in the province of Valdivia great patches of red clover which had been experimentally sown and had since grown wild, but were in no way inferior to the most carefully cultivated leys of the central valley. He considers that in the south, "where rainfall is frequent until the summer months, red clover does not appear to be given the importance really due to it", and elsewhere he writes that Chile has failed to take advantage of her red clover as Argentina has profited from her lucerne leys. (Vergara, 1938.)

TRIFOLIUM PRATENSE IN COLOMBIA

Abadia reports (1943) that *Trifolium pratense*, although little known in Colombia as yet, has a great future in that country as a hay and pasture plant in the so-called cold lands situated between approximately 6,500 to a little over 10,000 feet (between 2,000 and 3,050 m.). It is expected to furnish a good substitute for lucerne where the latter does not thrive. The average annual yield at La Picota Experiment Station, near Bogotá, is 65,000 kg. green weight per hectare, three to four cuts per year being obtainable.

It appears on the whole that appreciation of red clover as a component of leys in the cooler, moister localities is growing.

TRIFOLIUM FRAGIFERUM

Trifolium fragiferum (strawberry clover) has attracted attention in Argentina for its usefulness in low, shallow, marshy and even somewhat salt lands, in which it is difficult for other valuable forage plants to become established. Clos first recorded this introduced plant as growing wild in the vicinity of Buenos Aires in 1936, and in 1939 he found it again in another locality in greater abundance. (Clos, 1936, 1939.) More recently Fina and Cuccioli have urged its cultivation in the upper valley of the Río Negro, where salt and alkaline soils are common. They are totally unproductive but can be improved by means of washing, draining, and in some cases liming also, processes which need a variable amount of time and in any case several years. The subsequent use of a green manure is imperative, and *T. fragiferum* is considered ideal for this purpose because it is resistant not only to much moisture, but also to the considerable amount of salts always remaining in such land even after irrigation. It can be sown early, during the very process of washing, so that the land can be used for grazing while still under reclamation, and when the washing is completed the legume can be ploughed under without loss of time and organic matter can be supplied without resort to the customary, more protracted method of growing a lucerne crop before any other sowing is done. (Fina and Cuccioli, 1943.)

TRIFOLIUM INCARNATUM

Of the other clover species, *Trifolium incarnatum* is almost unknown in Argentina, except that it has recently been grown successfully in the Province of Entre Ríos and is said to be an excellent crop for spring green feed or grazing. It is cultivated in Chile to a certain extent. Opazo says its chief advantage is that it gives a soiling or grazing crop earlier than the other clovers, but on account of its pubescent leaves it is regarded as of less nutritive value for animals. As a result of trials, seed of this species is now being reproduced for distribution to Chilean farmers. Opazo regards it as more valuable as a green manure than as a forage plant, an opinion expressed also for Colombia (Abadia, 1943), where its wide range of adaptation to soil and climate is appreciated, but the fact that it is an annual is held to impair its value as a forage crop.

T. ALEXANDRINUM

T. alexandrinum has been tried in Argentina in the Provinces of Buenos Aires, Tucumán and Santa Fé, and is considered promising for humid, subtropical conditions. At Santa Fé, Schiel and Marcó found it sensitive to cold and greatly encouraged by inoculation. (Schiel and Marcó, 1943.) Seed from Palestine has been tested at La Estanzuela, Uruguay. It is valuable chiefly for the winter and beginning of spring, and Schiel and Marcó report that "two winter cuts of *T. alexandrinum* are more or less equivalent to two summer cuts of lucerne". This species is under trial at La Picota in Colombia.

TRIFOLIUM SUBTERRANEUM

Trifolium subterraneum, grown from Tasmanian seed, is under trial at La Estanzuela, Uruguay, where it is considered promising as a pasture plant, especially for sheep. Trials have also been made in Argentina. At Lobería near Necochea in the south-eastern part of the Province of Buenos Aires, subterranean clover has been grown for over ten years by a New Zealand settler. Some 500 hectares are devoted to it. Burkart, viewing these cultures in 1945, found them to be somewhat heavily mixed with other herbage. (Burkart, 1945b).

TRIFOLIUM HYBRIDUM

Opazo draws attention to the value of *T. hybridum* on account of its resistance—greater than that of *T. pratense*—to cold and moisture, but it is not known to what extent it is cultivated in Chile. It is possible that it may be found in the European colonies of southern Chile. Alsike

clover is under trial in Colombia, where it is as yet little known, and is found excellent in its adaptation to ordinary soils poor in lime and in its ability to thrive in marshy lands. Three to four cuts per year are obtainable at La Picota and an average yield of 69,125 kg. per hectare. In Argentina it is found adventitious and cultivated in forage mixtures in western Patagonia, and is considered promising for that region and for Tierra del Fuego.

OTHER SPECIES OF TRIFOLIUM

Trifolium filiforme grows in grasslands of the Paraná delta and near lake Nahuel Huapi; it is a useful plant, but too small to be conveniently sown. *T. campestre* is adventitious in the south of Brazil and is being grown experimentally in the La Plata region; in moist years it forms a sward of fine herbage and is readily adaptable, so that it might be worth disseminating for the improvement of lowland grazings. *T. spadiceum* is adventitious in Magallanes, the southernmost province of Chile, and might become of importance for the neighbouring Argentine lands. *T. strepens* has been found recently in the Nahuel Huapi region. (Burkart, 1943, 1945. Boerger, 1943. Opazo, 1939. Abadia, 1943.)

Parodi and Pastore record the following species as indigenous in Argentina: *Trifolium argentinense* and *T. polymorphum*, La Plata region, Entre Ríos and Corrientes, and *T. amabile* in the alpine meadows of the north-west. The last-named is a very useful species. (Parodi and Pastore, 1939. Burkart, 1943.) *T. amabile* grows wild in Colombia also, as well as *T. dubium*. (Abadia, 1943.)

(d) Other legumes.

Although the natural herbage of South America is deficient in legumes, a very large number of legume species are available for use as fodder in the different parts of the continent, for, in addition to the indigenous species, many European species have been introduced, intentionally or accidentally, since the advent of the colonists in the sixteenth century and have become naturalized. The species actually under cultivation are not, however, so very numerous, and much of the cultivation is of an experimental nature. Most of the research and experiment stations are conducting comparative trials of leguminous crops. Space allows the consideration of some typical cases only.

ARGENTINA AND BRAZIL

Burkart writes that in Argentina, apart from lucerne, few legumes are grown for forage. *Vigna sinensis* is becoming increasingly popular in the north of that country; one or two species of *Stizolobium* are cultivated in the hottest parts of Salta and Jujuy; *Cajanus indicus* is grown to a certain extent in Misiones, Corrientes and the Chaco. *Vicia sativa*, *V. villosa* and *V. benghalensis* are very promising as winter crops in a large part of the Republic, and *Glycine hispida* also is used for summer forage in Buenos Aires and the coastal provinces. For the north late varieties of *Arachis hypogaea* have been recommended, the straw of which is used for feeding animals. (Burkart, 1943). In this connexion attention is called to an interesting use of *Arachis prostrata* mentioned by Kok (1943), who recommends it for grazing leys in the Brazilian state of São Paulo, stating that it has rendered valuable service in this capacity in other pastures of that country. Kok recommends also for grazing *Indigofera* spp. and *Desmodium* (*Meibomia*) *barbatum*: for hay and soilage he considers an indigenous legume, *Desmodium discolor*, to be of special interest, and for field crops *Vigna sinensis*, *Pueraria thunbergiana* and *Mucuna*. All these plants are regarded as substitutes for *Medicago sativa*, which is always preferred when cultivable, but in very large areas of the continent conditions are unfavourable for its growth. Vincent also regards *Mucuna* as a valuable substitute for lucerne in São Paulo. (Vincent, 1939). The value of *Desmodium discolor* as a forage plant is supported by the Brazilian botanist Pio Corrêa, who

writes that it is a perfect substitute for the best European forage plants, including lucerne. The same author describes *D. affine*, an herbaceous species, as a good hay plant that is worthy of further study. It gives three or four cuts a year. Other species of *Desmodium* suggested for forage plants are *D. sclerophyllum*, *D. supinum*, *D. umbrosum* and *D. uncinatum*. *Zornia diphylla* is said to be a good substitute for lucerne, and two species of *Aeschynomene*, *A. falcata*, a prostrate plant that affords good forage, and *A. marginata*, are recommended as fodder. (Corrêa, 1931.)

DESMODIUM AND STYLOSANTHES

The Brazilian Ministry of Agriculture also recommends *Desmodium discolor* and *D. barbatum*, together with two other native legumes, *Stylosanthes guianensis* and *S. guianensis* var. *subviscosus*, as the best substitutes for lucerne in Brazil. The grazing of these legumes, however, is not absolutely recommended, not all being sufficiently resistant to trampling. It is considered that under an intensive system of farming the grazing of such leys would be unnecessary, although it is admitted that the procedure is more economical than cutting. These legumes are found in most parts of Brazil, some as far as the extreme north, are adapted to the generally acid soil and are more fitted than introduced, foreign plants to compete with the weeds that are apt to suppress the latter. Three to five cuts a year may be obtained, and the hay is excellent. *Stylosanthes guianensis* is the most nutritious of the four and bears a close qualitative resemblance to lucerne. (Brazil, Min. Agric. 1943b.)

Burkart notes that six species of *Stylosanthes* grow in Argentina, and that they are of some value as forage plants. (Burkart, 1943.)

Argüello recommends *Desmodium rensoni* for the highlands of Guatemala (1938). Mutinelli reports that, of several *Desmodium* species, in the poor, shallow soils of the Argentine province of Misiones *D. cuneatum* has exhibited especially valuable characters as a substitute for lucerne, in hay and mixtures and for renovating grasslands. It is both palatable and nutritious. (Mutinelli, 1939b). *D. uncinatum* is considered of interest for Colombia. (Abadia, 1943.)

VICIA

Vicia is represented in Argentina by eight to ten indigenous species, all natural herbage of value when present, but their scanty development renders them useless for cultivation, with the exception of *V. nigricans*, a valuable plant growing over a metre in height and found in the Patagonian woodlands. The species cultivated, *V. sativa*, *V. villosa* and *V. benghalensis*, are all introduced European species. (Burkart, 1943. Parodi and Pastore, 1939.) Trials of these three species are now in progress at La Estanzuela, Uruguay, where *V. benghalensis* and some subspecies of *V. sativa* are found to be the most suitable species for the production of green fodder during the cold season. Optimal sowing dates have been determined. (Henry, 1940-41 and 1941. Boerger, 1943.) *V. villosa* is under trial for the cooler parts of Colombia also, where it can be grown from altitudes of 1,360 metres to 3,600 metres. (Abadia, 1943.)

LUPINUS

There are many indigenous species of *Lupinus* in South America, in Argentina about fifteen, of which some might well be of interest for agriculture. Their trial is, however, still in prospect, and such lupins as are cultivated, experimentally or otherwise, are introduced annuals. The Agricultural Experiment Station of Tucumán, Argentina, is in possession of seed of the "sweet" or alkaloid-free strain of *Lupinus luteus*, which was imported from Germany in 1937 and is now in course of reproduction. It was hoped to begin distribution in 1943. (Burkart, 1943. Parodi and Pastore, 1939.)

MELILOTUS AND LATHYRUS

Melilotus indica is widely disseminated throughout Argentina, where it has assumed the proportions of a weed in certain parts, and *M. alba* has been grown for fodder in some regions

unsuitable for lucerne, but neither plant is popular with farmers. Approximately twenty indigenous species of *Lathyrus* are found in Argentina, distributed throughout the whole country with the exception of the great semi-arid regions. They are used as forage, especially in western Patagonia, where they are sometimes cut for hay, although some species are suspected of toxicity. The introduced European species are not as yet used for fodder, with the exception of the straw of *L. sativus*. *L. tingitanus* is under trial at La Estanzuela, Uruguay. (Burkart, 1943.)

LOTUS

In Chile *Lotus uliginosus* figures among species of herbage plants that are being reproduced for distribution by the Ministry of Agriculture. (Elgueta, 1944.)

LESPEDEZA, ETC.

It is possible that in future other legume species may also come to the fore. Burkart considers that *Lespedeza sericea* should be tested for use in northern and central Argentina (Burkart, 1943), and at the Tucumán Agricultural Experiment Station this plant has actually given excellent results. In his 1941 report Cross states that *Lespedeza striata* and *Lespedeza stipulacea* were unable to compete with the natural vegetation, but *L. sericea* thrived well, and although stock appeared to find this plant unpalatable at first, eventually they acquired the taste and grazed it readily enough. The Station is of opinion that *L. sericea* has a promising future under Tucumán conditions, especially where lucerne does not grow successfully. It has given good results at altitudes from 1,400 to 1,500 metres, with fairly heavy frost and moderate precipitation. Two to three cuts per year may be obtained. It has not yet been possible to determine the plant's resistance to trampling. *Melilotus alba* has given excellent results at the same Station. (Cross, 1942.) *Lespedeza sericea* is also under trial, together with *Melilotus altissima*, at the Agricultural Experiment Station of Belo-Horizonte, Brazil. (Silva, 1934a.) *Melilotus alba*, *Ornithopus sativus* and *Hedysarum coronarium* are being studied for Colombian conditions at the Agricultural Experiment Station of La Picota, near Bogotá. (Abadia, 1943.) Ayala recommends for the Argentine Territory of Misiones *Centrosema pubescens*, both as a forage plant and for soil improvement. (Ayala, 1943.)

ADESMIA

Attention has been drawn by Muñoz and Suarez to the forage possibilities of the genus *Adesmia*. It is endemic in southern South America, especially in Chile and Argentina, and in the former country is found in all types of country from the extremely dry lands of Tarapacá to others with an annual rainfall exceeding 5 m. (Magallanes). According to K. Reiche (Flora de Chile, 1898. Vol. 2) 146 species exist in Chile, but a critical revision is considered necessary. There are perennial and annual species, and a diversity of habit from shrubby species, such as *A. arborea*, to herbaceous. A study has been made of the nutritive value of certain species, and tabulated data on the chemical composition of the following are presented: *A. smithiae* (annual), *A. latistipula* (herbaceous), *A. cinerea* (small shrub), *A. glaucescens* (undershrub), *A. viscida*, *A. brachycarpa*, and *A. landbeckii*, the last three all perennials. The protein value is in general high, ranging from 9 to 19 per cent (*A. smithiae*). The plant is held to offer a valuable forage resource, especially in regions having a long summer dry season, and to be useful also for soil conservation. (Muñoz and Suarez, 1945.)

CALOPOGONIUM

Isaza has written on the nutritive value of *Calopogonium mucunoides*, which grows wild and in abundance in certain regions of the province of Antioquia, Colombia. This is believed to be one reason why these districts are so valuable for stock raising. Chemical analysis shows the plant

to be little less nutritious than lucerne. Graziers are urged to propagate the plant as much as possible. (Isaza, 1942.)

LEGUME TRIALS IN GUATEMALA AND VENEZUELA

There is much activity in Guatemala at present in the trial of various legumes for their value both as green manure and as fodder. The following genera are concerned: *Acacia*, *Albizzia*, *Leucaena*, *Cajanus* (1 species each), *Crotalaria* (4 species), *Cassia* (4 species), *Tephrosia* (7 species), *Canavalia* (2 species), *Calopogonium* (2 species), *Centrosema* (1 species), *Pueraria* (2 species), *Vigna* (3 species), *Indigofera* (4 species), *Mimosa*, *Phaseolus*, *Glycine*, *Lupinus* (1 species each). Twenty-five of the species listed grow wild in Guatemala, the rest are relatively recent introductions. (Ippisch, 1945.) The following species have been discussed in rather more detail: *Canavalia gladiata*, *C. obtusifolia*, *Vigna unguiculata*, a *Lathyrus* species, *Crotalaria spectabilis*, *C. speciosa*, *Lupinus albus* (bitter), and *L. montanus*, an indigenous lupin which grows wild in all the higher regions of Guatemala, but has not given such good results as *L. albus*, being less leafy than the latter. The *Lathyrus* species mentioned has been very successful in the colder parts of Guatemala: only 15 kg. seed are required per hectare and give a yield of 400 kg. and over per hectare. (*Revista agricola, Guatemala*. 1945.)

In trials of twenty-five legumes grown for the reclamation of seriously eroded wheat lands in the Andean regions of Venezuela, eight have developed satisfactorily, namely, *Medicago hispida*, *Melilotus indica*, *M. officinalis*, *M. alba*, *Lotus corniculatus*, *Trifolium carolinianum*, *T. repens* (Ladino variety) and *T. pratense*. *Vigna vexillata* has also given excellent results. (See p. 198. Klugh and Rugeles, 1944. Rugeles, 1944.)

GLYCINE HISPIDA

The growing of *Glycine hispida* in South America has received a great stimulus in recent years, but food for human consumption rather than forage has been envisaged. Trials at Tucumán indicate, however, that in the Tucumán region of Argentina the soybean is very susceptible to adverse climatic conditions and is more promising there as a forage than as a grain crop. (Cross, 1942.)

Watkins writes that in El Salvador the value of soybeans as a forage has been proved many times. (Watkins, 1946.)

In Guatemala, also, the growing of soybeans for fodder is contemplated, especially for those lands in which lucerne is unsuccessful. Trials of twenty-seven forage type varieties commonly grown in the United States have shown that in Guatemala the varieties Ootootán and Avolleyes thrive best, yields of 30 and 50 quintals per hectare having been produced at Chimaltenango and Bárcena respectively. Data on the varietal characters and behaviour of different soybeans under different conditions of environment and treatment are being collected from Guatemalan growers. (Sierra, 1944-45.)

In Colombia, according to Garcia, soybean trials at the Agricultural Experiment Station, Palmira, have been for the most part of early varieties which complete their vegetative growth within 80 to 120 days according to climate and soil. The soybean becomes well acclimatized in temperate to hot regions, but is not successful at altitudes exceeding 1,500 metres. Trials at the Campinas Agricultural Institute show the plant to grow well in any soil having an abundance of potassium and phosphorus and a pH value of over 4, but to be more successful when there is also plenty of lime. Inoculants improve the results obtainable and may be procured from the Colombian National Department of Agriculture free of cost. Garcia gives information on the chemical composition of the soybean at different stages of maturity, with a view to its use as green fodder. (Garcia, 1944.)

(e) Grasses

Although the great natural grazings remain the centre of gravity of the South American stock-raising industry, sown leys of grasses have become increasingly important as intensification continues.

SORGHUM SUDANENSE

Herein the sorghums and in particular Sudan grass (*Sorghum sudanense*) play a prominent part. Parodi estimates the Sudan grass area in Argentina as over 80,000 hectares. It is grown in the subtropical regions as far as the south of the province of Buenos Aires. (Parodi, 1942*d*.) It furnishes a valuable summer fodder. In trials at Tucumán it developed well, producing an abundance of palatable forage which was, however, of short duration, and it is considered that rich, well-fenced fields or flat land are necessary for its successful cultivation, where erosion resulting from the action of the plough is not easily produced. (Cross, 1942.) Schultz describes optimal cultural technique for the Tucumán province. (Schultz, 1940.) The question of toxicity has naturally attracted attention. In a two-year trial of Sudan grass for fattening lambs in summer, conducted in Uruguay, Costa found that not only had the grass no toxic effect on the sheep, but it exhibited curative properties in respect to worm infestation. In this case the leys were grown under poor conditions, but results were nevertheless satisfactory, and under better conditions and with animals of better quality still more advantageous results would have been obtained. (Costa, 1940.)

SORGHUM POISONING

Much study has been devoted to the question of sorghum poisoning, and reference will be made to this in a subsequent chapter, but attention may be drawn here to the findings of Girola, who—in discussing the variable toxicity of *Sorghum sudanense* and *Sorghum vulgare* var. *saccharatum*—noted that (a) the proportion of cyanogenic glucoside is greater during the early stages of growth, in fresh shoots produced after cutting, and when fresh growth is induced by rain or other influences after a period of repose; (b) the proportion of this glucoside is less when the plant is completely developed and vegetation has taken place under normal conditions; (c) in certain periods no toxic phenomena are apparent; (d) desiccation, and conversion into hay or silage render the plants innocuous. Animals introduced gradually to this fodder acquire a certain immunity; the sudden taking of large quantities may have disastrous results. Veterinary measures suitable in such cases are noted. (Girola, 1933.)

OTHER SORGHUMS

Sorghum alnum is an important species in Argentina, for it is perennial and earlier than Sudan grass, produces a greater quantity of hay and grows well in the dry zone, being very resistant to the effects of erosion. (Parodi, 1945.)

Recently broom corn, *Sorghum dochna* var. *technicum*, has been grown for grazing in the province of Buenos Aires (Balcarce and regions of the west). The ranchers sow it densely and are careful to graze sufficient animals to prevent the *Sorghum* from seeding, that is to say, they do not allow it to flower, so that it may remain tender herbage. Its advantages over Sudan grass are the extreme cheapness of the seed and its greater resistance to drought; disadvantages are that the fodder is coarser and not so fattening. (Burkart, 1945.)

CHLORIS GAYANA

Another important grass for subtropical conditions and summer feed is Rhodes grass, or *Chloris gayana*, introduced from South Africa. Parodi speaks of it as being practically equal in importance with Sudan grass for Argentina, where it is widely cultivated in the same regions. (Parodi, 1942*d*.) At Tucumán it is considered very promising as supplementary forage for cattle, horses and sheep, preferably in fenced fields. (Cross, 1942.) Schultz publishes instructions for cultivation under Argentine conditions. (Schultz, 1940.) In Uruguay, Costa, in the two-year trial of summer leys for fattening lambs already mentioned, found the Rhodes grass ley unable to

tolerate the severity of grazing by sheep. (Costa, 1940.) At La Estanzuela, however, it is considered promising and seed is being reproduced. In trials at this Station it was found resistant to drought (Boerger, 1943. Henry, 1939), and at Tucumán to recover after frosts (Cross, 1942). The Brazilian Ministry of Agriculture also finds it resistant to cold and recommends it both for cutting and for grazing. For the last-named purpose it may be sown in pure cultures or with legumes and other plants. Being tolerant of trampling by animals, it is protective of other herbage such as lucerne. It can also serve for hay and silage, giving from four to seven cuts annually. It may be grown in practically all parts of Brazil, but requires fertile soil and is better for manuring. It should not be grown for many years in succession in the same spot, because of the ensuing soil exhaustion : growing in rotation with a forage legume is recommended. (Brazil, Min. Agric. 1943a.) *Chloris gayana* is recommended for temporary leys in Guatemala (Argüello, 1938) and is under trial at La Picota in Colombia, where 42,500 kg. green weight per year can be obtained. Unfortunately the seed produced in the last-named country is dear and of poor germination capacity, a fact which has hitherto prevented its wider diffusion. (Abadia, 1943.)

PENNISETUM SPECIES

Pennisetum clandestinum or Kikuyu grass, another African grass that was introduced into South America a relatively short time ago, has already become more or less important for temporary leys. It has given very successful results in the south Brazilian State of Rio Grande do Sul (Avila de Araújo, quoted by Boerger, 1943), is under trial at Belo-Horizonte (Silva, 1934a), and, on the basis of experiments conducted by Cardoso at the Biological Institute of São Paulo, is considered by the Brazilian Ministry of Agriculture to offer the Brazilian rancher and dairy farmer a valuable means of supplying the nutrients, nitrogen in particular, which are lacking from the native grazings at certain seasons and especially in periods of drought. (Brazil, Dir. Est. Prod., 1937.) It is considered promising in trials at La Estanzuela, Uruguay. (Henry, 1939. Boerger, 1943.) Ayala recommends it for the Argentine Territory of Misiones (Ayala, 1943) and Argüello for temporary leys in the uplands of Guatemala (Argüello, 1938).

In Colombia, perhaps, the greatest degree of success is seen. Piñeros reports in 1933 that *Pennisetum clandestinum*, first introduced into the Department of Boyacá in 1931, is now widely distributed in every part and has proved of great value on account of its adaptability to all kinds of soil and temperature, its ability to conserve moisture, to give good results with little cultivation, and to grow on land where nothing else will grow. The defect noted by American farmers, namely, the yellowing of the lower leaves, has not been noted in this region. Its behaviour under cold, temperate, and warm conditions respectively is described. (Piñeros, 1933.) Galindo, in the same year, writes that Kikuyu grass has been grown with very successful results in a salt soil area where practically no other crop will grow. Salt land of this description covers a considerable area of the Savannah of Bogotá and other parts of the country, and it is suggested that it may be converted into useful grassland by means of Kikuyu grass. Seed is available from the Ministry of Industries. (Galindo, 1933.) It has been successfully grown in Colombia at altitudes ranging from below 1,000 metres to over 3,000 metres, although better results have been obtained in the intermediate climates. Of all the herbage plants at present under trial at the Station of La Picota, Kikuyu grass is one of the most promising in regard to adaptability, ready propagation, palatability and nutritive value. Its average annual yield there is 37,500 kg. green weight per hectare. (Abadia, 1943.)

Pennisetum purpureum is of less importance. It has given good results in trials at La Estanzuela, Uruguay, where it proved particularly resistant to drought. (Boerger, 1943.) It is under trial at Belo-Horizonte, Brazil (Silva, 1934), and is recommended by Argüello as a soilage crop for Guatemala (Argüello, 1938). At Tucumán, in Argentina, it grew vigorously at an altitude of

1,500 m. and was readily eaten by stock, but proved insufficiently hardy for the frosts characterizing the region. (Cross, 1942.)

BROMUS SPECIES

Bromus catharticus is a grass of much importance for sown leys in Argentina. It furnishes winter feed, is very resistant to trampling, and readily propagated by seed. (Parodi, 1942*d*.) The breeding of this grass is in progress at an Argentine Research Institute in the province of Santa Fé. (Boerger, 1943.) For the western Argentine province of San Luis, Canela recommends *Bromus inermis*, introduced from the Old World, for cutting or grazing leys, generally alone but also in mixtures. (Canela, 1940.) In Chile several species and varieties of *Bromus* are under trial for their usefulness in that country, and reproduction of *B. catharticus* and *B. carinatus* was begun in 1942. The former is considered the most promising *Bromus* species. (Buchner, 1942*b*.)

PHALARIS SPECIES

Phalaris minor is increasingly grown in the Argentine pampa, especially in the north of the province of Buenos Aires, probably introduced in *P. tuberosa* var. *stenoptera*, of which it is a well-known adulterant. Growers eulogize its vigour and quality, which is considered superior to that of barley. Comparison of the palatability of *P. minor* and barley respectively was made in a four-hectare field composed half of the grass and half of the barley. The cows, horses and pigs that were grazed there at different times all invariably showed a marked preference for the *Phalaris*, only turning their attention to the barley when the grass was exhausted. (Parodi, 1937*f*, 1942*d*.) The Ministry recommend this grass for winter forage in northern Argentina. (Lecube, 1942.)

Schelotto, in the 1941-42 report of the Experiment Station of La Previsión, Argentina, includes an account of a trial of *Phalaris minor* as a winter forage plant, sown on April 17th and May 12th. The first sowing produced in August a green weight cut equivalent to 20,000 kg. per hectare; the aftermath was kept for seed for fresh trials. The second sowing gave in October a green weight yield equivalent to 40,000 kg. per hectare, and was then left to seed. The vigour and healthiness of the crops gave a favourable impression, and 100 plants were selected to be tested for productivity, resistance to grazing and trampling, etc. The 45 best plants were to be re-sown in 1942. (Schelotto, 1942*a*.)

Trials in progress at La Estanzuela show *P. minor* to be of importance for conditions in Uruguay. It is grown there also in a mixture with *Vicia benghalensis*. (Boerger, 1943.)

Phalaris tuberosa var. *stenoptera* is of less importance, but is cultivated in Argentina to a certain extent for winter feed, and is considered approximately equal to barley in nutritive value. (Valencia, 1937.)

Dowling recommends a mixture of lucerne and *Phalaris bulbosa* (probably *P. minor*) for the province of Buenos Aires; seeding rate 15 kg. lucerne and 5 kg. *Phalaris* per hectare. (Dowling, 1942.)

Correa reports favourable results from a trial of *Phalaris tuberosa* at Llo-Lleo in Chile, but the plant was a failure in the northern Department of Ovalle, even under irrigation, on account of the climate. (Correa, 1941.) Seed of *P. tuberosa* is now being reproduced for distribution in that country. (Elgueta, 1944.)

LOLIUM SPECIES

Introduced grasses that are more or less under trial for herbage leys are ryegrass and, more recently, cocksfoot. *Lolium multiflorum* is cultivated in the province of Buenos Aires as a winter forage crop, but *L. perenne* is little grown and cocksfoot is practically unknown in this region.

(Parodi, 1939c.) Trials of ryegrass have been in progress at La Estanzuela, Uruguay, since 1913, as well as attempts at acclimatization. The heat of the Uruguayan climate is inimical to ryegrass, but in 1937 a sowing of *Lolium perenne* obtained from the Hawke's Bay region of New Zealand, where it had been cultivated for over forty years, withstood the summer heat well and has now been under six years' uninterrupted cultivation and is exhibiting a considerable degree of resistance to heat and drought. It may yet become of value for winter leys. Trials of *Lolium multiflorum* at La Estanzuela have shown the grass to be of value not so much in the winter, but in the first warmth of spring, when it develops luxuriantly. (See p. 148. Boerger, 1943.) Reference has already been made to J. Spangenberg's trials of *L. multiflorum* as a winter ley in comparison with oats, in which the ryegrass had the advantage. (See p. 148.)

Lolium is under trial at La Picota for use in the uplands of Colombia. *L. perenne* produces 24,500 kg. green weight per hectare per year at that Station; *L. italicum* (= *L. multiflorum*) 180,000 kg., cut every 70 days and irrigated when necessary. (Abadia, 1943.)

In Chile, in connexion with acclimatization trials now being conducted in different parts of the country, seed of *L. perenne* and *L. multiflorum* is being reproduced for distribution. (Elgueta, 1944.) Argüello (1938) recommends *L. perenne* as a soiling crop for the uplands of Guatemala.

DACTYLIS GLOMERATA

Dactylis glomerata has proved very successful in certain regions of Colombia, where it grows at altitudes ranging from 2,000 to 3,200 metres, and the range could probably be extended, but the grass is not well known in the country and exact information is lacking. At various places in the central Andean Cordillera, in fertile volcanic soils, it has given excellent results. The average annual yield green weight per hectare at La Picota is 40,000 kg. The fact that some farmers have found it unsatisfactory is attributed to its having been left to ripen too much, in the vain hope of obtaining optimal yields both of herbage and of seed. (*Bol. Agric. Colombia*, 1933. Abadia, 1943.) It is successful also in the highlands of Peru. (Méndivil, 1941.)

In Argentina *Dactylis glomerata* is grown for cutting and grazing on a large ranch in Balcarce (in the south-east of the province of Buenos Aires), and abundant crops are obtained. In addition it is seeded to a certain extent and has spread in the western part of Argentine Patagonia, where it is appreciated for grazing cows. (Burkart, 1945.)

AGROPYRON CRISTATUM

Agropyron cristatum has been tried at Tucumán, in Argentina, but was unable to compete with the natural vegetation. (Cross, 1942.) In Chilean trials, however, it has distinguished itself by resistance to drought and capacity for growth under low temperatures. (Buchner, 1942c.)

MELINIS MINUTIFLORA

Melinis minutiflora, said to have been introduced into South America from Africa through the slave trade, is perhaps the most well-known and widely distributed grass in Brazil, especially in the pastoral regions of the States of Minas Gerais, Rio de Janeiro, São Paulo and Espírito Santo.

It is a perennial, forming dense tufts 1 m. wide by 0.80 m. in height, and has four varieties, the red (the most widely distributed and cultivated), the white, "negro's hair" (in reference to the wavy appearance of culms and leaves), and Francano, similar to but more vigorous than the red variety, emanating from Franca in the State of São Paulo. Broadcasting at the rate of 15 to 18 kg. per hectare is the general custom, but propagation by tillers is occasionally practised. The principal merits of the grass are: hardiness; modest requirements as regards soil quality; tolerance of drought and trampling; palatability; great productivity; it suppresses weeds; produces an abundance of seed which may be purchased cheaply; is easily cultivated; serves principally as pasture, then as hay, green fodder, and silage; and is of high nutritive value. (Brazil, Min. Agric.

1935.) While this grass has escaped and is now a common component of natural grasslands, it is also sown for herbage leys. Mutinelli conducted trials at Loreto in the Argentine territory of Misiones from 1933-38. The usefulness of the grass, especially for the grazing of cattle, was demonstrated. It is resistant to drought, trampling, and close cutting, but cannot tolerate a temperature of less than -2.5°C. , nor can it bear burning. The grass is of medium nutritive value, but superior in this respect to many species which compose the natural grassland of the region. It is of value for consolidating the soil and may usefully be employed on steep slopes; its weed-suppressing capacity, further, is of value. Average seed production, 285 kg. per hectare. (Mutinelli, 1939a.)

Melinis minutiflora has the disadvantage in Argentina of not resisting heavy frosts and of disappearing under rather severe winters. Burkart has not seen it cultivated to any considerable extent. (Burkart, 1945.)

In Colombia *M. minutiflora* is regarded as an ideal forage grass. It may be reproduced by means of seeds or by cuttings. Fifteen kg. seed per hectare is necessary for broadcasting, and 8 kg. per hectare for drilling. The best time for sowing is from September to November, the ground having been previously tilled, manured and harrowed. It gives from three to four cuts annually, with a yield of about 40,000 to 50,000 kg. per hectare: 190 to 200 kg. seed per hectare may be obtained in a year and from 12,000 to 13,000 kg. hay. (*Bol. Agric. Colombia*, 1932.) Watkins records that in El Salvador, Central America, he has observed this grass to be used most commonly as a soiling crop, and that it is rarely found as a dominant pasture plant. (Watkins, 1946.)

AXONOPUS SCOPARIUS

Axonopus scoparius or "micay" is used in Colombia for cutting, as feed for dairy cows and horses. It grows well in land having good moisture supplies. (Rueda and Reyes, 1941.) In Brazil also, this grass is recommended as a soiling crop, but not for hay, ensilage or grazing. It is winter hardy, tolerant of heat and, in fertile soil, of drought. It should, nevertheless, be fed with other rations because if used alone it tends to produce scouring. (Brazil, Min. Agric. 1934b.)

OTHER GRASSES

Only a brief reference can be made to *Panicum maximum* and its varieties, to *Hyparrhenia rufa*, *Axonopus compressus*, *Cynodon dactylon*, *Panicum purpurascens*, *Paspalum dilatatum*, *P. notatum*, *Tripsacum* spp. and other tropical and subtropical species, as these grasses, though often cultivated, tend to become permanent pasture rather than to be used for the temporary leys here under discussion.

(f) Other plants

There may be mentioned in passing one or two other plants cultivated for stock feed. Pio Corrêa (1931) notes that comfrey, *Symphytum asperinum*, an introduced plant, is grown in the Brazilian States of São Paulo and Rio Grande do Sul as valuable forage, especially good for dairy cows. *S. officinale* also is grown in several of the Brazilian States. *Opuntia inermis* is cultivated in some dry regions (Domingues, 1941; Barros, 1943); and in El Salvador farmers commonly grow an area of banana, *Musa sapientum*, the leaves of which can be cut and fed to stock at the beginning of the dry season (Watkins, 1946). *Saccharum officinarum* and *S. sinense* are also grown for feed in many parts.

(g) General observations. Mixtures

Hitherto the tendency in South America has been to grow forage crops, whether for soiling, hay, or pasture, in pure cultures, but it is recognized by the scientists of the respective countries that, especially where the cereals and grasses are concerned, the use of mixtures is far more advantageous. The subject of their composition is under investigation in many parts; breeding and acclimatization work frequently envisages the production of plant types suitable for use in mixtures; and the desirability of using mixtures rather than pure sowings is from time to time stressed in the various agricultural periodicals.

Rueda and Reyes write that in Colombia there is now a growing tendency to plant newly cleared land with sown leys, and the Government is making experiments in the transformation of the natural savannahs by the same means. The necessity of using varied herbage and of growing legumes by the side of the grasses is emphasized. The heavy initial cost of establishing such leys is considered to be more than compensated by the results obtained. "If one hectare of pasture will keep a cow for one year, the same hectare sown with soilage crops will keep four or more." The crops recommended are lucerne and red clover for the cold and medium hot zones, for the hot lands *Desmodium (Meibomia) adscendens*, *D. discolor*, *Calopogonium mucunoides*, *Cajanus indicus*, *Stizolobium deeringianum*, *Vigna sinensis*, *Crotalaria* spp., the cereals *Zea mays* and *Avena*, and the grasses *Lolium* spp. and others. These authors state that in the establishment of such leys the propagation of the forage legumes is of supreme importance, and record that, in their anxiety to keep sown grass or cereal leys free of "weeds", graziers have in the past actually eradicated legumes as undesirable intruders. This error has, however, been corrected by means of official propaganda. (Rueda and Reyes, 1941.)

Special studies of mixtures for leys are in progress at La Estanzuela, Uruguay, and are concerned with mixtures of cereals, of cereals plus Sudan grass, of cereals grown with *Vicia sativa*, *V. benghalensis*, and of the same *Vicia* species grown with *Phalaris minor*. (Boerger, 1943.) Katz (1943) gives compounds suitable for various purposes in Ecuador. In Chile, experiments are being conducted at the National Agricultural Society's Experiment Station with a view to furnishing information to farmers on the mixtures and quantities offering the greatest prospect of success in the different regions of Chile. Emphasis is laid on the superiority of mixtures over pure sowings, the value of legumes in mixtures, and the value of a legume-grass two or three-year ley in cereal rotations. (Buchner, 1942d.)

Torroba recommends sowing even the Argentine lucerne ley in a mixture on certain occasions, using winter cereals or linseed. The practice ensures first a yield of grain and secondly a forage ley of great productivity with a single process of sowing and cultivation. Such sowings are generally made in the winter (July) in Argentina, although normally lucerne is not sown at this time. Experiments at the Alberti Experiment Station in the Province of Buenos Aires have shown, however, that pure sowings of lucerne have a better initial development than lucerne sown under a cereal, are less liable to weed growth, can be cut in the summer immediately after sowing and are in general more productive and persistent. For this reason pure sowings are recommended for the east and north-east of the province of Buenos Aires, although the mixed culture can be used on occasion on small farms where it is not desired to retain a lucerne ley for more than two or three years. (Torroba, 1943.)

Writing of El Salvador, Watkins notes that the growing of legumes with grasses (apparently uncommon as yet) is a practice which should be encouraged. (Watkins, 1946.)

(h) Weed suppression

Zubiaur and Lorenzini, studying the problem of weed growth in Argentine cultures and pastures, suggest among means of control the growing of herbage or forage plant leys, the continuous cutting and grazing of which prevent the seeding of weed plants. (Zubiaur and Lorenzini, 1944.)

(i) Ley farming

In considering the South American temporary leys it is significant that ley farming, as such, hardly exists. The leys are grown primarily to cover seasonal shortages of feed and to supply wanting nutritional elements, but not for any part they may play in a cropping system. Crop rotations, for the most part, are still to seek. Land owners have cashed in on the natural resources

of the continent by raising those products—whether cattle, horses, cereals, coffee, sugar or other commodities—that happen to give high returns, and those products only.

Exceptions to what has been said above are found in the central region of Chile and in certain relatively small pockets of European settlers, as, for example, in the coastal region of Rio Grande do Sul, Brazil; in the west of Uruguay; and in the German settlements of certain parts of southern Chile, in all of which more diversified types of farming may be found.

Another, and an important exception is the lucerne ley of Argentina, which has already been described (pp. 21-2 and 136-41). This affects some five and a half million hectares of land in Argentina.

The various Ministries of Agriculture and the scientific institutes in particular have become keenly aware of the disadvantages that have accrued from continuous unilateral use of the South American lands, and in many parts serious efforts are being made, through experimentation and propaganda, to introduce rotational cropping or greater diversification or both. Some account of this work will be given in a later chapter. An increase in the number of general farms, generally such as are primarily dairy farms, is already to be seen in, for example, the Argentine province of Santa Fé, and the vicinity of the larger centres of population in Brazil and Chile.

(j) Spreading and reversion

It has been noted by Parodi that cultivation and the spreading of plants from cultures and leys has caused profound modifications in the vegetation of, at all events, the Argentine pampa. (Parodi, 1930.) It is probable that this is the case elsewhere also, and with plants such as lucerne the modification may be, at least temporarily, all to the good. That this is not always so, however, is indicated by observations of outrun lucerne leys in Argentina made by Davies. This author notes that the outrun ley does not revert to the original pampa sward, but that another, and often a poorer type of grassy herbage arises in which *Cynodon dactylon* and *Panicum* predominate rather than the indigenous grasses of the pampa. "The outrun ley will keep animals in breeding condition, but they will not fatten." These reverted leys, *Cynodon-Panicum-Paspalidium-Paspalum* and similar types, are described as "induced exotic grasslands", and the change that is brought about is compared to a similar process observed on the hills of Wales, where "the disturbance of the natural *Molinia-Nardus-Festuca* grasslands and the introduction of the grazing animal as well as cultivation result in *Agrostis-Holcus-Trifolium* grasslands". (Davies, 1940.)

CHAPTER 8

BROWSE PLANTS, POISONOUS AND UNDESIRABLE PLANTS

(i) Browse plants

The forage shrub and tree appear to represent Nature's solution of the dry season problem as the temporary ley represents the agronomist's. The importance of these plants in, for example, the arid north-east of Brazil, where for many successive weeks they represent the only grazing available to animals, has already been noted (pp. 100-5); and Johnson writes of Mexico that during the dry season some cattle get their entire nourishment from mesquite (*Prosopis juliflora*) and similar plants. (Johnson, 1944.)

IMPORTANCE

It is not only as an emergency fodder, however, that browse plants are significant, for in many parts the forage shrub and tree constitute throughout the year the principal, if not the sole source of feed for stock. Beetle notes that in Patagonia "the woody plants, an extremely important part of the available forage, vary from practically absent to as high as 88 per cent". (Beetle, 1943.) His figure is obtained from the study of the grasslands of the Argentine and Patagonia made by William Davies, who has described a Patagonian area in which the percentage cover of 88 is made up as follows: *Empetrum rubrum*, 80; *Baccharis magellanica*, 5; *Pernettya pumila*, 3. The same author describes a sheep station of which the main pasture type is shrub steppe with *Verbena tridens* as the dominant shrub, grazed during the winter months; another having salt lands covered with a 3- to 4-foot high canopy of scrub, some elements of which are edible and grazed, a few, however, distinctly poisonous; and other areas in which shrubs over 6 inches high together with edible woody herbs, chiefly a species of *Lepidophyllum*, constitute 86, 64, 51 and 82 per cent respectively of the plant cover. In these last-named areas the aggregate contribution of herbaceous plants is thus very low, in two cases only 14 and 18 per cent. Sheep are raised successfully on such land, although the stocking capacity is low. (Davies, 1940.)

The browse plants constitute also a source of moisture, as in the case of plants such as *Opuntia ficus-indica*, *Ficus benjamina* and similar species that are of great value in arid regions. (Fernandes e Silva, 1936.)

PRESENT STATE OF INFORMATION

The grazier has a lively sense of the importance of browse plants, and he is practically the only person who knows what species are used by and are of value to stock. Scientific information is both scanty and scattered. As Burkart, the Argentine botanist, writes: "It is certain that the country people, so familiar with the life of their stock, possess a fount of knowledge on the best kinds of 'herbage' on their lands and can generally point out to the stranger who is interested those species which have particular value as forage. But the practical knowledge of these cattle-men is generally restricted to the locality concerned, and only slowly and gradually is it becoming available for the agronomist because the best means of communication, the scientific name, is wanting. Conversely, the botanist is endowed with an ample knowledge of the flora but is ignorant of its applications unless he has notes made by collectors, or himself makes personal observations on his tours. Under these circumstances there exists an evident necessity to unite forces in order to arrive at a complete knowledge of the natural forage resources in the different parts of the country." (Burkart, 1943.) Writing of Venezuela, Pittier says: "Many legumes and other plants participate in the feeding of stock roaming free on the grazings, but it would require detailed observation to differentiate them all from those which are rejected by the animal". This author

has drawn up a preliminary list based on his own investigations and on information obtained from farmers, to which reference will be made later. (Pittier, 1926.)

Information is available that in Santiago del Estero (Argentina) the cattle crop the shoots and young leaves of various trees and shrubs such as *Schinopsis lorentzii*, the algarrobos (*Prosopis alba*, *P. nigra*, *P. panta*, etc.), *Ephedra tweediana*, *Acacia moniliformis*, etc. In Neuquen and Rio Negro the leaves of *Maytenus boaria* are eaten by cattle. In Misiones teamsmen are accustomed to feed their horses on the leaves and tips of *Arecastrum romanzoffianum*. In Paraguay cattle are turned out into the " monte " or scrub to eat the fruits of the palm *Acrocomia totai* and are subsequently driven back to the corral, where the valuable oil-bearing kernels of the fruit, dropped by the cattle and cleaned by the rains, are recovered for industrial purposes. (Parodi, 1945.)

The only reliable source of information, obviously, is the grazing animal, which is known to be eminently selective. In this connexion Myers' observations on differing selection by bullocks and horses respectively in the savannahs of the interior Guiana plateau, although they refer to herbaceous plants only, are of interest (p. 132). If deliberate studies of animals' selection on the range could be made in a variety of tropical and subtropical countries at different latitudes, a volume of valuable information would result.

A Bulletin on forage shrubs and trees has been prepared as Joint Publication No. 10 of the Imperial Bureau of Pastures and Forage Crops, Aberystwyth, and the Imperial Forestry Bureau, Oxford, working in collaboration. In the meantime, while it has not yet been possible to make an exhaustive study of the species known to be used for grazing and fodder in South America, the preliminary list which follows is presented as offering some indication of the types of plant concerned.

LIST OF TREES, SHRUBS, AND OTHER BROWSE PLANTS EATEN BY OR FED TO STOCK IN LATIN AMERICA

Some of the species listed are introduced plants.

- Abelmoschus esculentus*, (chimbombó), Mexico. Cultivated. Leaves and young shoots used for fodder. Martinez, 1936.
- Acacia* spp., (cujies), Venezuela. Fruits eaten. Pittier, 1926.
- Acacia arabica* (arvore da gomme arabica), Brazil. Young shoots, leaves, and pods when green give good fodder. Pio Corrêa, 1926.
- Acacia aroma*, (tusca), Argentina. Fresh shoots, dry leaves, and fruits eaten. Burkart, 1943a, 1945. Hieronymus, 1874, reprinted 1945.
- Acacia cavenia*, (espino), Chile. Shoots and leaves grazed in summer, especially good for sheep. Opazo G., 1939.
- Acacia cebil*, (cebil), Tucumán, Argentina. Leaves, which fall in winter, afford good fodder for cattle. Hieronymus, 1874, reprinted 1945.
- Acacia cymbispina*, (chirowi, guinora, sinala), Sonora, Mexico. Legumes ripen in autumn and are eaten by asses and mules. Gentry, 1942.
- Acacia macracantha*, (cuji negro), Venezuela, Peru. Pods are good feed for cattle. Goats will not eat the leaves. Pittier, 1926. Alberts, 1947.
- Acacia moniliformis*, (tusca), Tucumán, Chaco, Argentina. Fruits eagerly eaten by animals, afford good nutriment. Hieronymus, 1874, reprinted 1945. Parodi, 1947: Chap. 3 of this Bulletin.
- Acicarpha procumbens*, Uruguay. Annual. Eaten to a small extent, when young, by animals. Rosengurtt, 1943.

- Acrocomia sclerocarpa*, (coco de catarrho), Brazil. Costa Rica. Leaves eaten, especially good for dairy cows. It has been necessary to place legal restrictions on the cutting of this palm in Costa Rica. Pio Corrêa, 1931.
- Acrocomia totai*, Brazil, Paraguay. Eaten by cattle. Araujo, 1935. Parodi, 1945.
- Adenocalymma alliaceum*, (cipó de alho), Brazil. If grazed by cattle, it renders the meat and milk uneatable. Pio Corrêa, 1931.
- Adesmia* spp. Argentina. Herbs, natural forage plants. Burkart, 1943a.
- Adesmia arborea*, (varilla brava), Chile. Opazo G., 1939.
- Adesmia bicolor*, (babosita), Argentina, Uruguay. Herb furnishing good fodder. Burkart, 1943a.
- Adesmia cinerea*, (varilla mansa), Chile. Opazo G., 1939.
- Adesmia incana*, Buenos Aires, Argentina, and Uruguay. Herb. Burkart, 1943a.
- Adesmia latifolia*, Uruguay. Perennial herb which furnishes grazing throughout the year. Tends to become scarce under grazing. Rosengurtt, 1943.
- Adesmia muricata*, (alverjilla), San Luis, Argentina. Herb. Burkart, 1943a.
- Aeschynomene americana*, (carrapicho), Brazil. Undershrub. Furnishes good forage. Pio Corrêa, 1931.
- Aeschynomene sensitiva*, (corticeira do campo), Brazil. Leaves eaten. Pio Corrêa, 1931.
- Aesculus hippocastanum*, (castaño), Guatemala. Nuts fed to pigs. Aguilar G., 1939.
- Aextoxicon punctatum*, (olivillo, tique), Chile. Eaten by horned cattle. Opazo G., 1939.
- Agave* spp., (maguey), Mexico. Bases of young shoots eaten. Navarrete, 1945.
- Albizzia lophantha*, Argentina. Grazed by cattle. Burkart, 1943a.
- Alternanthera philoxeroides*, (gamba rosa), Uruguay. Herb eaten by cattle. Rosengurtt, 1943.
- Amaranthus quitensis*, (cararu), Brazil. Green feed, principally for pigs. Araujo, 1935.
- Ambrosia polystachya*, (cravorana), Brazil. Undershrub. The leaves, which are nutritious, are eaten. Pio Corrêa, 1931.
- Amicia andicola*, Argentina. Herbaceous legume, eaten by cattle. Burkart, 1943a.
- Amicia fimbriata*, Argentina. Herbaceous legume, eaten by cattle. Burkart, 1943a.
- Amicia medicaginea*, Argentina. Herbaceous legume, eaten by cattle. Burkart, 1943a.
- Anarthrophyllum* spp., Argentina. The less spinous species serve as feed for goats and sheep. Burkart, 1943a.
- Anarthrophyllum rigidum*, Chile. Opazo G., 1939.
- Apium ammi*, (eneldo), Uruguay. Annual, eaten by cattle, but not much. Rosengurtt, 1943.
- Apodanthera biflora*, (yuca de monte), north-western coastal zone of Peru. Alberts, 1947.
- Araucaria angustifolia*, Misiones, Argentina. Kernels fed to stock. Burkart, 1945a.
- Araucaria araucana*, Neuquén, Argentina. Kernels fed to stock. Burkart, 1945a.
- Arecastrum romanzoffianum*, Argentina, Brazil. Palm. Leaves fed to cattle, fruits to pigs. Araujo, 1935. Burkart, 1945a.
- Aristotelia macqui*, (maqui), Argentina. Burkart, 1945a.
- Artocarpus communis*, (arbol del pan), Mexico. Leaves and young shoots, both green and dry, eaten. Martinez, 1936.
- Artocarpus incisa*, (arbol de pan), Guatemala. Seeds. Aguilar G., 1939.
- Artocarpus integrifolia*, (mazapán), Guatemala. Pulp of the fruits. Aguilar G., 1939.
- Aster squamatus*, Uruguay. Herb, eaten by sheep. Rosengurtt, 1943.
- Atriplex atacamensis*, (cachiyuyo), Chile. Grazed, but not very eagerly. Opazo G., 1939.
- Atriplex coquimbana*, (pasto cenizo), Chile. Grazed by sheep especially. Opazo G., 1939.
- Atriplex deserticola*, (piyaya), Chile. Grazed, but not very eagerly. Opazo G., 1939.
- Atriplex repanda*, (sereno), Chile. Grazed by sheep especially. Opazo G., 1939.

- Atriplex semibaccata*, Brazil, Chile (introduced). Pio Corrêa, 1926. Opazo G., 1939.
- Attalea phalerata*, (auacury), Brazil. Leaves are excellent fodder. Pio Corrêa, 1926. Araujo, 1935.
- Attalea princeps*, Matto Grosso, Brazil. Eaten by horses. Araujo, 1935.
- Avellanita*, (avellanita, bustillosi). Chile. Shrub, without latex. Leaves eaten. Behn, 1944.
- Baccharis artemisioides*, (altamisa), Brazil. In times of scarcity eaten by cattle, but a disagreeable flavour is imparted to the milk. Pio Corrêa, 1926.
- Baccharis racemosa*, (chilca), Chile. Eaten by animals in the mountains when there is heavy snowfall and no other feed is available. Opazo G., 1939.
- Baccharis trimera*, (carqueja), Uruguay. Undershrub, common, young and tender shoots eaten by sheep. Rosengurttt, 1943.
- Bastardia viscosa*, (chivatera), Venezuela. Favourite browse of goats. Has a strong smell. Pittier, 1939.
- Bauhinia forficata*, (mooró, unha de boi, unha de vaca), Ceará and Paraíba, Brazil. Domingues, 1941. Barros, 1943. Souza, 1943.
- Beloperone squarrosa*, (sacha-alfalfa, mania-caballo), Argentina. Burkart, 1943c.
- Benthhamania glabrescens*. Serves occasionally as forage. Burkart, 1943a.
- Berroa gnaphalioides*, Uruguay. Perennial herb, eaten a little by sheep. Rosengurttt, 1943.
- Borreria leiophylla*, (yerba charrúa), Uruguay. Herb, eaten by animals. Rosengurttt, 1943.
- Bowdichia virgilioides*, (sacupira, sapupira, sebépira, sicupira, sucupira), Ceará, Brazil. Souza, 1943.
- Bradburya* (choncho), El Salvador. Herbaceous, viny legume with fruiting pods in the dry season. Watkins, 1946.
- Bradburya sagittata*, (cuñha), Brazil. Creeper. Pio Corrêa, 1931.
- Bridgesia incisifolia*, (rumpiato), Chile. Opazo G., 1939.
- Bromelia laciniosa*, (macambira), Ceará, Brazil. Domingues, 1941.
- Brosimum alicastrum*, (capomo), Mexico. (Ramon), Guatemala. Leaves eaten, green or dry. Fruits used for fattening domestic animals. J. G. Salas, 1935. M. Martinez, 1936. C. L. Lundell, 1937.
- Caesalpinia bracteosa*, (catinga, catingueira), Ceará, Brazil. Souza, 1943.
- Caesalpinia corymbosa*, (charan), Peru. Alberts, 1947.
- Caesalpinia ferrea* var. *cearensis*, (jucá, etc.), Ceará, Brazil. Souza, 1943.
- Caesalpinia pyramidalis*, (catingueira), Ceará, Brazil. Domingues, 1941.
- Calopogonium*, (choncho), El Salvador. Herbaceous, viny legume with fruiting pods in the dry season, Watkins, 1946.
- Calopogonium brachycarpum*, (falso oro), Brazil. Araujo, 1935.
- Canavalia* sp., (feijão bravo), Ceará, Brazil. Domingues, 1941.
- Cannabis sativa*, (canhamo verdadeiro), Brazil. Herbaceous, fresh leaves used as a fodder. Pio Corrêa, 1926.
- Capparis scabrída*, (sapote), Peru. Alberts, 1947.
- Cardamine chenopodiifolia*, Uruguay. Much grazed, but of insignificant value. Rosengurttt, 1943.
- Carica chilensis*, (= *Vasconcellea chilensis*), (palo gordo), Chile. Roots eaten. Opazo G., 1939.
- Cassia acuta*, (alcaparra), Chile. Eaten by all animals except horses. Opazo G., 1939.

- Cassia crassiramea*, (sumalagua), Jujuy, Argentina. Eaten by goats. Burkart, 1943a.
- Cassia ferruginea*, (canafistula), Ceará, Pernambuco, Brazil. Leaves eaten. Fernandes e Silva, 1936. Souza, 1943.
- Cassia fistula*, (canafistula), Brazil. Araujo, 1935. Souza, 1943.
- Cassia multijuga*, (canafistula), Ceará, Brazil. Domingues, 1941.
- Cassia rotundifolia*, (acacia rasteira), Brazil. Gives good hay. Araujo, 1935.
- Cassia tora*, (matapasto), Pernambuco, Brazil. Recommended for hay or silage. Fernandes e Silva, 1936.
- Castanea vesca*, (castanheiro da Europa), Brazil (introduced). Leaves used. Pio Corrêa, 1931.
- Casuarina equisetifolia*, (chorão), Brazil. Leaves eaten. Pio Corrêa, 1931.
- Casuarina glauca*, (casuarina), Brazil. Leaves eaten. Pio Corrêa, 1931.
- Casuarina stricta*, (casuarina), Brazil. Leaves eaten. Pio Corrêa, 1931.
- Ceiba pentandra*, (pochote), Mexico. Seed refuse used for cattle fodder after extraction of the oil. Martinez, 1936.
- Celosia argenta*, (amaranto branco), Brazil. Herb. Good fodder. Pio Corrêa, 1926.
- Celtis chiensis*, (coatindiba), Brazil. Fruits used for fattening domestic animals. Pio Corrêa, 1931.
- Centaurea chilensis*, (escabiosa), Chile. Opazo G., 1939.
- Centrosema virginianum*, Argentina. Herb. Forage plant, but susceptible to trampling. Burkart, 1943a.
- Ceratonia siliqua*, (algarroba europea), Argentina. Guatemala. Brazil. Fruits eaten. Pio Corrêa, 1926. Aguilar G., 1939. Burkart, 1945a.
- Cercidium* sp. (unidentified), (dipúa), Lower California, Mexico. Shoots and fruits eaten; said to fatten cattle rapidly. Martinez, 1945.
- Cercidium peninsulare*, (palo verde), Lower California, Mexico. Young shoots and fruits eaten. Martinez, 1945.
- Cereus* sp., (cardeiro), Ceará, Brazil. Domingues, 1941.
- Cereus eburneus*, Guatemala. Shoots chopped and fed to cattle in the dry season. Aguilar G., 1943.
- Cereus gounellei*, (chique-chique), Pernambuco, Brazil. Singed to destroy spines. Fernandes e Silva, 1936.
- Cereus jamacaru*, (mandacará), Ceará, Pernambuco, Brazil. Fernandes e Silva, 1936. Domingues, 1941.
- Cereus stramineus*, Guatemala. Shoots chopped and fed to cattle in the dry season. Aguilar G., 1943.
- Cereus undatus*, Guatemala. Shoots chopped and fed to cattle in the dry season. Aguilar G., 1943.
- Chaetothylax umbrosus*, (uchu-yuyo), Argentina. Relished by horses. Burkart, 1943c.
- Cissampelos* sp., (orelha de onça), Paraíba, Brazil. Barros, 1943.
- Cissus sicyoides*, (caro, bejuco de caro), Venezuela. Fruits eaten. Pittier, 1926.
- Cocos nucifera*, (coqueiro da Bahia), Brazil. Young leaves used as fodder. Pio Corrêa, 1931.
- Colliguaya odorifera*, (coliguai), Chile. Opazo G., 1939.
- Colocasia antiquorum*, (inhame), Brazil. Araujo, 1935.
- Commelina nudiflora*, (lochoch), Guatemala. Herbaceous plant eagerly grazed. Aguilar G., 1939.
- Copernicia cerifera*, Brazil. Eaten by cattle. Araujo, 1935.
- Cordia alliodora*, (anacahuite), Mexico. Fruits eaten by pigs and other animals. Martinez, 1936.
- Cordia decandra*, (carbonillo), Chile. Eaten by all animals except horses. Opazo G., 1939.

- Cordia oncocalyx*, (pau branco), Ceará, Pernambuco, Brazil. Domingues, 1941. Fernandes e Silva, 1936. Souza, 1943.
- Cordia rotundifolia*, (overal), Peru. Alberts, 1947.
- Cratylia mollis*, (camaratuba), northern Brazil. Leaves eaten; good forage plant. Burkart, 1943a.
- Crescentia alata*, (morron, etc.), El Salvador. A tree. The fruits which fall to the ground are eaten green or in a fermenting condition by stock during the dry season. In some areas possibly the only source of feed. Said to result in good quality cheese. Watkins, 1946.
- Cristaria hispida*, (malvilla), Chile. Opazo G., 1939.
- Crotalaria retusa*, (chique-chique, xique-xique), Brazil. Undershrub, should be used as forage plant. Pio Corrêa, 1931.
- Cryptocarya peumus*, (peumo), Chile. Opazo G., 1939.
- Cupania sapida*, (arbol de hueva), Guatemala. Fruits, previously boiled. Aguilar G., 1939.
- Cytisus proliferus*, (tagasaste), Chile. Opazo G., 1939.
- Dalea parryi*, Sonora, Mexico. Eaten by deer. Gentry, 1942.
- Dalea polygonoides*, Sonora, Mexico. Eaten by cattle. Gentry, 1942.
- Dasyilirion* spp., (sotol), Mexico. Used especially for dairy cows. Martinez, 1936.
- Desmanthus depressus*, (tagasaste), Uruguay. Herb. Grazed. Rosengurt, 1943.
- Desmodium*. See also *Meibomia*.
- Desmodium* spp., Argentina. Herbs; good natural forage plants which replace the clovers in tropical regions. Burkart, 1943a.
- Dicliptera jujuyensis*, (uchu-yuyo), Argentina. Undershrub, considered good forage. Burkart, 1943c.
- Dicliptera tweediana*, (canario rojo, ajicillo), Argentina, Uruguay. Burkart, 1943c. Rosengurt, 1943.
- Diodia dasycephala*, Uruguay. Herb, eaten by animals but not of importance. Rosengurt, 1943.
- Dioscorea batatas*, (cara), Brazil. Araujo, 1935.
- Dioscorea convolvulacea*, Guatemala. Tubers used, boiled, steeped or dried and converted into meal. Aguilar G., 1943.
- Diplothemium campestre*, (ariry), Brazil. Leaves eaten. Pio Corrêa, 1926.
- Dolichopsis paraguariensis*, Argentina. Herb. Probably a forage plant. Burkart, 1943.
- Echium plantagineum*, (flor morada, lengua de vaca), Uruguay. Herb. Annual. Eaten by animals, chiefly by sheep. Rosengurt, 1943.
- Eclipta alba*, Uruguay. Annual, eaten by animals. Rosengurt, 1943.
- Eichhornia azurea*, (mururé de flôr roxa), Amazonas, Brazil. Herb. Considered one of the best of fodders. Pio Corrêa, 1926.
- Elephantopus angustifolius*, (lengua de vaca), Venezuela. Palatable to cattle. H. Pittier, 1926.
- Elephantopus mollis*, (lengua de vaca), Venezuela. Palatable to cattle. Pittier, 1926.
- Elephantopus scaber*, (lengua de vaca), Venezuela. Palatable to cattle. Pittier, 1926.
- Empetrum rubrum*, Magallanes, Chile. Patagonia, Argentina. Opazo G., 1939. Davies, 1940.
- Encelia oblongifolia*, (incienso), Chile. Opazo G., 1939.
- Encholirion spectabile*, (macambira), Paraíba, Brazil. Eaten by cattle after it has been singed. Barros, 1943.
- Enterolobium cyclocarpum*, (conacaste), Guatemala. Fruits eagerly eaten. Aguilar G., 1939.
- Ephedra andina*, (pingo pingo), Chile. Opazo G., 1939.

- Ephedra tweediana*, Santiago del Estero, Argentina. Parodi, 1945.
- Erigeron bonariensis*, (yerba carnícera), Uruguay. Annual. Much eaten, especially by sheep, and imparts a disagreeable flavour to the mutton when taken in large quantities. Rosengurt, 1943.
- Erigeron chilensis*, Uruguay. Herb, eaten by animals. Rosengurt, 1943.
- Erigeron montevidensis*, (yerba carnícera), Uruguay. Annual herb, much eaten. Rosengurt, 1943.
- Erodium cicutarium*, (tupu-tupu, etc.), Cuzco, Peru. Chile. Herrera, 1930. Opazo G., 1939.
- Eryngium ebracteatum*, Uruguay. Much eaten by animals. Rosengurt, 1943.
- Eryngium echinatum*, Uruguay. Much eaten by sheep. Rosengurt, 1943.
- Eryngium elegans*, Uruguay. Much eaten. Rosengurt, 1943.
- Eryngium nudicaule*, (cardilla chica), Uruguay. Leaves and heads, when young, eaten by sheep. Rosengurt, 1943.
- Eryngium paniculatum*, (cardilla), Uruguay. Leaves and heads, when young, eaten by sheep. Rosengurt, 1943.
- Eryngium sanguisorba*, Uruguay. Rosengurt, 1943.
- Erythrina mulungu*, (muchoco, etc.), Ceará, Brazil. Souza, 1943.
- Escallonia arguta*, (ñipa, corontillo, lunca, lun), Chile. Eaten by horses and cattle. Opazo G., 1939.
- Escallonia mutis*, (ñipa), Chile. Opazo G., 1939.
- Eucryphia cordifolia*, Chile. The decomposed wood of fallen trunks eaten with avidity by cattle in preference to grasses such as *Dactylis* and *Lolium*. Reichert, 1929, quoted by Burkart, 1945.
- Eupatorium* sp., Sonora, Mexico. Eaten by cattle. Gentry, 1942.
- Eupatorium buniifolium*, (chirca, chilca), Uruguay. Shrub, young shoots eaten by sheep. Rosengurt, 1943.
- Euphorbia lancifolia*, (ixbut), Guatemala. Especially good for milk production, but should be used as a concentrate in carefully balanced rations. Aguilar G., 1939.
- Fabiana viscosa*, (pichamilla), Chile. Opazo G., 1939.
- Facelis retusa*, Uruguay. Annual, eaten by sheep in stubble fields, where it attains a height of 10 to 20 cm., but in virgin grassland it remains almost a dwarf plant. Rosengurt, 1943.
- Ficus benjamina*, Pernambuco, Brazil. Introduced. Leaves eaten. Fernandes e Silva, 1936.
- Ficus padifolia*, (cush), Guatemala. Leaves eaten. J. G. Salas, 1935. Aguilar G., 1939.
- Flourensia riparia*, Salta, Argentina. Burkart, 1945.
- Frankenia* sp., (dichilla, vichilla), Chile. Grazed, especially by sheep and goats. Opazo G., 1939.
- Franseria cordifolia*, (chicurilla), Sonora, Mexico. Eaten by cattle and horses; regarded by natives as good pasturage. Gentry, 1942.
- Galactia*, (choncho), El Salvador. Herbaceous, viny legume with fruiting pods in the dry season. Watkins, 1946.
- Galactia gracillima*, Uruguay. Herb. Disappears under grazing. Rosengurt, 1943.
- Galinsoga parviflora*, Uruguay. Annual. Rosengurt, 1943.
- Goffraea superba*, (umariseira), Ceará, Brazil. Souza, 1943.
- Geranium albicans*, Uruguay. Perennial herb, common, much grazed. Rosengurt, 1943.
- Gleditschia triacanthos*, (acacia negra, espinheiro da Virginia), Argentina, Brazil. Seeds eaten by pigs. A meal made of the pods and seeds is used as a feeding-stuff for cattle. Pio Corrêa, 1931. Burkart, 1943a, 1945a.

- Glycyrrhiza astragalina*, Argentina. Eaten by sheep. Burkart, 1943a.
- Gossypium*, Ceará, Brazil. Grazed by cattle after cotton has been picked. Domingues, 1943.
- Gourliea spinosa*, (chañar), Argentina. Fruits eaten. Goats (but not other animals) eat the leaves. Burkart, 1943a, 1945a.
- Guarea trichiloides*, (carrapeta verdadeira), Brazil. Leaves eaten. Fruits eaten by pigs. Pio Corrêa, 1931.
- Guazuma tomentosa*, (camacan), Brazil. Leaves eaten. Pio Corrêa, 1926.
- Guazuma ulmifolia*, (guácimo, caulote), Venezuela. Guatemala. Fruits eaten. Pittier, 1926. Aguilar G., 1939.
- Gynierum argenteum*, (cortadera), Chile. Evergreen. Opazo G., 1939.
- Haplopappus parvifolius*, (crespilla), Chile. Young shoots eaten by all kinds of animals. Opazo G., 1939.
- Haylockia pusilla*, Uruguay. Dwarf bulb plant, very resistant to heavy grazing. Rosengurt, 1943.
- Helicostylis* sp., (ajuste), Guatemala. Leaves, flowers and fruits eagerly eaten. Aguilar G., 1939.
- Herreria ophiopogonoides*, Uruguay. Hemicryptophyte. Apparently grazed, for in pastures the flowering shoots are not allowed to develop and the plant finally disappears. Rosengurt, 1943.
- Hibiscus sabdariffa*, (cararú azedo), Brazil. Shrub. Seeds used. Pio Corrêa, 1931.
- Hura polyandra*, (habilla de San Ignacio), Mexico. Dried leaves eaten by cattle. Sap poisonous. Martinez, 1936.
- Hymenoclea monogyra*, (romerillo), Lower California, Mexico. Used as forage in dry seasons. Martinez, 1945.
- Indigofera* spp., Brazil. Generally considered to be forage plants. Pio Corrêa, 1926.
- Indigofera lespedezioides*, (raiz de la Virgên), Venezuela. The whole plant very palatable to cattle. Pittier, 1939.
- Indigofera pascuorum*, (raiz de la Virgên), Venezuela. Avidly eaten by cattle. Pittier, 1926.
- Inga affinis*, (inga), Ceará, Brazil. Souza, 1943.
- Inga paterno*, (paterna), Guatemala. Seeds used, either boiled or pulped and dried. Aguilar G., 1939.
- Ipomoea arborescens* var. *glabra*, (palo santo), Sonora, Mexico. Fallen corollas eaten by deer. Gentry, 1942.
- Ipomoea batatas*, (batata doce), Brazil. Leaves and tubers eaten. Araujo, 1935.
- Ipomoea glabra*, (gitirana), Paraíba, Brazil. Barros, 1943.
- Ipomoea hederacea*, (dulce de mula), Guatemala. Aguilar G., 1939.
- Ipomoea pentaphylla*, (dulce de mula), Guatemala. Aguilar G., 1939.
- Ipomoea purpurea*, (dulce de mula), Guatemala. Aguilar G., 1939.
- Ipomoea sagittata*, (dulce de mula), Guatemala. Aguilar G., 1939.
- Ipomoea setifera*, (campainha vermelha), Brazil. Creeper. Leaves eaten. Pio Corrêa, 1926.
- Ipomoea triloba*, (dulce de mula), Guatemala. Aguilar G., 1939.
- Justicia campestris*, (alfalfita, quebrarao), Argentina. Shrub, highly nutritive, said to be especially palatable when frozen or semi-frozen. Burkart, 1943c.
- Justicia echegarayi*, (albahaca de vaca), Argentina. Burkart, 1943c.
- Kageneckia oblonga*, (bollén), Chile. Opazo G., 1939.

- Lantana brasiliensis*, (cambará branco), Brazil. Leaves eaten. Pio Corrêa, 1926.
- Lantana camara*, (camará), Paraíba, Brazil. Barros, 1943.
- Lantana chamaedrifolia*, (cambará, camará), Brazil. Pio Corrêa, 1926.
- Lantana mista*, (cambará de duas côres), Brazil. Leaves eaten. Pio Corrêa, 1926.
- Lantana radula*, (cambará, camará), Brazil. Leaves eaten. Pio Corrêa, 1926.
- Lantana undulata*, (cambará, camará), Brazil. Leaves eaten. Pio Corrêa, 1926.
- Lathyrus crassipes*, Uruguay. Annual, much eaten by cattle and tends to disappear from heavily grazed land. Common, but quantity of forage furnished is insignificant. Rosengurt, 1943.
- Lathyrus paranensis*, Uruguay. Tends to disappear from heavily grazed pastures. Rosengurt, 1943.
- Lecythis pisonis*, (sapucaia), Ceará, Brazil. Souza, 1943.
- Lepidophyllum* sp., Patagonia, Argentina. Davies, 1940.
- Leucaena glauca*, Argentina. Eaten by cattle and goats, but causes loss of hair in horses. Burkart, 1943a.
- Leucaena trichodes*, (chamba), Cuzco, Peru. Leaves fed to cattle and horses; said to produce falling of hair, especially from the tail, in the latter. Herrera, 1930.
- Lithraea molleoides*, (molle), Chile. Opazo G., 1939.
- Lithraea venenosa*, (litre), Chile. Dry leaves eaten by cattle, goats and sheep. Opazo G., 1939.
- Llagunoa glandulosa*, (atutema), Chile. Opazo G., 1939.
- Lomatia dentata*, (monte negro), Chile. Opazo G., 1939.
- Lomatia ferruginea*, (romerillo), Chile. Opazo G., 1939.
- Malvaviscus arboreus*, (malvavisca), Chile. Drought-resistant shrub, shoots and leaves eaten. Opazo G., 1939.
- Manihot dulcis*, (yuca dulce, guacamote dulce, guhyaga), Mexico. Cultivated. Fed to various herbivores. Martínez, 1936.
- Manihot grahamii*, Misiones, Argentina. Leaves. Burkart, 1945a.
- Manihot palmata*, (aipim), Brazil. Tubers and leaves used as fodder. Pio Corrêa, 1926.
- Manihot utilisima*. Tubers. Burkart, 1945a.
- Marlierea edulis*, (cambucá verdadeiro), Brazil. Fruits eaten. Pio Corrêa, 1926.
- Marrubium vulgare*, (toronjil cuyano), Chile. Drought-resistant, eaten by all animals except horses. Opazo G., 1939.
- Maytenus boaria*, (maitén), Patagonia, Argentina, Brazil, Chile. Leaves of great nutritive value. According to Opazo not eaten by horses. Pio Corrêa, 1926. Opazo G., 1939. Tortorelli, 1941. Parodi, 1945.
- Maytenus chilensis*, (maitén), Chile. Opazo G., 1939.
- Medicago arborea*, (alfalfa arborea), Chile. Opazo G., 1939.
- Medicago hispida* var. *denticulata*, (trébol de carretilla), Uruguay. Famous herbage plant. Seeds eaten by sheep in periods of shortage. Rosengurt, 1943.
- Meibomia*. See also *Desmodium*.
- Meibomia adscendens*, (carrapicho de beijo de boi), Brazil. Shrub. Good fodder. Pio Corrêa, 1931.
- Meibomia discolor*, (carrapicho), Brazil. Important and cultivated as fodder. Pio Corrêa, 1931.
- Meibomia platycarpa*, (carrapicho), Brazil. Shrub. Forage plant, and, though not very leafy, valuable on account of root-conditioned resistance to drought and burning. Pio Corrêa, 1931.
- Meibomia spiralis*, (engorda magro), Pernambuco, Brazil. Fernandes e Silva, 1936.

- Melanthera aspera*, (orozuz), El Salvador. Herbaceous plant. Watkins, 1946.
- Melia azedarach*, (cinnamomo), Brazil. Leaves eaten. Pio Corrêa, 1931.
- Melocactus* sp., (corôa de frade), Pernambuco, Brazil. Fernandes e Silva, 1936.
- Melochia tomentella*, Sonora, Mexico. Browsed by cattle. Gentry, 1942.
- Mikania micrantha*, Uruguay. Perennial herb. Eaten by animals, disappearing under grazing. Rosengurt, 1943.
- Mimosa* spp., (cujies), Venezuela. Fruits eaten. Pittier, 1926.
- Mimosa cabrera*, (cují cabrero), Venezuela. Eaten by goats, seeds fatten these animals rapidly, but cause congestion. Pittier, 1926.
- Mimosa caesalpiniiifolia*, (sabiá), Ceará, Pernambuco, Brazil. Fernandes e Silva, 1936. A. J. de Souza, 1943.
- Mimosa vernicosa*, (jurema branca), Ceará, Brazil. Souza, 1943.
- Monttea chilensis*, (uvillo), Chile. Opazo G., 1939.
- Morus alba*, (amoreira branca), Brazil. Leaves fed to stock. Pio Corrêa, 1926.
- Muehlenbeckia chilensis*, (mollaca, quilo), Chile. Opazo G., 1939.
- Musa sapientum*, (bananeira, guineo de seda, guineo patriota), Brazil. El Salvador. Leaves fed green to stock. Araujo, 1935. Watkins, 1946.
- Neocracca heterantha* var. *minor*, Jujuy, Argentina. Leaves eaten by goats. Burkart, 1943a.
- Neoglaziovia variegata*, (caroá), Paraíba, Pernambuco, Brazil. Leaves eaten, and the plant is dried and ground to a meal. Fernandes e Silva, 1936. Scarlet flowers eaten by cattle. Leaves not eaten unless when deprived of the fibre, which is used for textiles. Barros, 1943.
- Nothofagus dombeyi*, Chile. The decomposed wood of fallen trunks eaten with avidity by cattle in preference to grasses such as *Dactylis* and *Lolium*. Reichert, 1929, quoted by Burkart, 1945a.
- Nymphaea rudgeana*, (aguapé da meia noite), Brazil. Herb. Leaves eagerly grazed by cattle. Pio Corrêa, 1926.
- Ocimum selloi*, (albahaca cimarrona), Uruguay. Herb, eaten by animals. Rosengurt, 1943.
- Oenothera indecora*, (yerba del mote), Uruguay. Herb eaten by cattle. Rosengurt, 1943.
- Opuntia dillenii*, (cacto), Brazil. The joints, when deprived of the spines, serve as forage, and though not very nutritious, are of value in periods of fodder scarcity. Pio Corrêa, 1926.
- Opuntia ficus-indica*, (palmatoria), Pernambuco, Brazil; Argentina. Fernandes e Silva, 1936. Burkart, 1945a.
- Opuntia inermis*, Brazil; Mexico. Araujo, 1935. Domingues, 1941. Barros, 1943. Navarrete, 1945.
- Opuntia mamillata*, (cholla), Sonora, Mexico. It is principally on the joints of this plant that lowland cattle subsist during the dry spring season. Gentry, 1942.
- Oxybaphus micranthus*, (r'ata-r'ata), Cuzco, Peru. Used in Urubamba as good forage for pigs. Herrera, 1930.
- Pachyrrhizus angulatus*, (jicama), Mexico. Herb. Cultivated. Leaves eaten. Martinez, 1936.
- Pachyrrhizus erosus*, Costa Rica. Orozco, 1939.
- Pachyrrhizus palmatilobus*, Costa Rica, Guatemala. Starchy root used. Orozco, 1939. Aguilar G., 1943.
- Pamphalea heterophylla*, Uruguay. Small annual herb, eaten a little. Rosengurt, 1943.
- Parkinsonia aculeata*, (cina-cina), Argentina and Mexico. Said to be a forage plant in Mexico. Burkart, 1943a.

- Parmentiera edulis*, (cuajilote), Guatemala. Fruits eaten by pigs. Aguilar G., 1939.
- Persea americana*, (aguacate), Mexico. Fruit pulp eaten by many animals. Martinez, 1936.
- Persea gratissima*, (abacateiro), Brazil. Fruits eaten by all kinds of animals, especially domestic animals. Pio Corrêa, 1926.
- Petiveria alliacea*, (mapurite), Venezuela. Eaten by cows, but imparts a garlic smell to milk. Pittier, 1926.
- Phaseolus*. Over 18 wild spp. in Argentina, almost certainly forage plants. Burkart, 1943a.
- Pilocereus setosus*, (xique-xique), Ceará, Brazil. Domingues, 1941.
- Piptadenia* spp., Argentina, (cujies), Venezuela. The dry leaves afford a secondary fodder. Burkart, 1943a. Fruits eaten. Pittier, 1926.
- Piptadenia communis*, (camoeteiro, jacaré, etc.), Ceará, Brazil. Souza, 1943.
- Piptadenia moniliformis*, (catanduba), Brazil. Leaves said to be innocuous if grazed, but poisonous if cut and fed to animals some hours afterwards. This statement not yet scientifically proved. Pio Corrêa, 1931.
- Pithecolobium* sp., (jurema branca), Ceará, Brazil. Domingues, 1941.
- Pithecolobium dulce*, (huamúchil), Mexico. Fruits eaten by cattle. Burkart, 1943a.
- Pithecolobium ligustrinum*, (orore), Venezuela. Considered good feed for goats, which fatten even on the dry leaves. H. Pittier, 1926.
- Pithecolobium mexicanum*, (palo chinu), Sonora, Mexico. Fallen corollas eaten by livestock. Gentry, 1942.
- Platanus acerifolia*, Argentina. Burkart, 1945a.
- Podanthus mitiqui*, (mitrio), Chile. Opazo G., 1939.
- Polygonum bowenkampfi*, (cobrizo), Chile. Creeping, woody plant, grazed especially by sheep and goats. Opazo G., 1939.
- Polygonum persicarioides*, (oyo-oyo, arroz-arroz), Cuzco, Peru. Herrera, 1930.
- Pontederia cordata*, (camalote), Uruguay. Eaten to a certain extent by animals. Rosengurtt, 1943.
- Populus* spp., Argentina. Burkart, 1945a.
- Populus nigra*, (choupo preto), Brazil, introduced. Chopped leaves used as fodder. Pio Corrêa, 1931.
- Portieria hygrometra*, (guayacán), Chile. Eaten by sheep and goats. Opazo G., 1939.
- Porophyllum ruderale*, (anamú, namú), Venezuela. Eaten by cattle, but communicates to meat and milk a repugnant odour. Pittier, 1926.
- Portulaca oleracea*, (verdolga), north-western coastal zone of Peru. Alberts, 1947.
- Proboscidea altheifolia*, (yuca de caballo), north-western coastal zone of Peru. Alberts, 1947.
- Prosopis* spp., (cujies), Venezuela. Fruits eaten. Pittier, 1926.
- Prosopis alba*, (algarroba), Argentina ; Brazil. Pods eaten. Pio Corrêa, 1926. Burkart, 1945a. Parodi, 1945c.
- Prosopis alata*, (algarroba), Argentina. Fruits eaten. Burkart, 1945a.
- Prosopis caldenia*, (algarroba), Argentina. Fruits eaten. Burkart, 1945a.
- Prosopis campestris*, (alpataco), Brazil. Pods eaten. Pio Corrêa, 1926.
- Prosopis chilensis*, (algarroba, mesquite, hupala), Argentina ; Mexico ; Peru. Leaves, flowers and fruits eaten. Gentry, 1942. Burkart, 1945a. Alberts, 1947.
- Prosopis dulcis*, (algarrobo), Chile. Leaves and pods furnish excellent feed for all animals, especially sheep and horses. Kaerger, 1937.
- Prosopis juliflora*, (algarrobo, mezquite), Brazil ; Chile ; Guatemala ; Mexico. Leaves and fruits give excellent fodder which can be kept from one year to another. According to Opazo, horses eat the fruits only. Pio Corrêa, 1926. Martinez, 1936. Aguilar G., 1939. Opazo G., 1939.

Prosopis nigra, (algarroba), Argentina. Fruits eaten. Burkart, 1945a, Parodi, 1945c.
Prosopis panta, (algarrobo), Santiago del Estero, Argentina. Parodi, 1945c.
Prosopis ruscifolia, (vinal), the Chaco, Argentina. Fruits eaten. Parodi (Chap. 3 of this Bulletin).
Prosopis tamarugo, (tamarugo), Chile. Opazo G., 1939.
Psoralea glandulosa, (culén), Chile. Eaten by all animals except horses. Opazo G., 1939.

Quercus, Argentina. Burkart, 1945a.

Quercus grandis and other species, (encino, roble), Guatemala. Acorns fed to pigs. Aguilar G., 1939.

Quercus pedunculata, (carvalho da Europa), Brazil (introduced). Chopped leaves are good emergency fodder. Pio Corrêa, 1931.

Rhynchosia, (choncho), El Salvador. Herbaceous, viny legume with fruiting pods in the dry season. Watkins, 1946.

Rhynchosia senna, (porotillo), Uruguay. Herb. Grazed, and resistant to grazing, but yields very little. Rosengurt, 1943.

Ricinus communis, (higuerilla), Chile. Eaten by all animals except horses. Opazo G., 1939.

Robinia pseudo-acacia, (acacia blanca), Argentina. Burkart, 1943a, 1945a.

Rosmarinus officinalis, (romero), Chile. Opazo G., 1939.

Ruellia sp., (melosa), Ceará, Brazil. Domingues, 1941.

Ruellia bahiensis, (uchu-yuyo), Argentina. Undershrub, drought-resistant, reputed to be good forage. Burkart, 1943c.

Rustia bracteosa, (ruda), Chile. Opazo G., 1939.

Salicornia sp., (sosa), Chile. Opazo G., 1939.

Salix spp., Argentina. Burkart, 1945a.

Salsola kali, (monte espinoso), Chile. Creeping spinous plant of sand dunes. Grazed when young, especially by sheep and goats. Opazo G., 1939.

Salvia procurrens, (hierba terrestre), Uruguay. Herb eaten by animals, tending to diminish in grazings. Rosengurt, 1943.

Samanea saman, (samán), Venezuela ; Colombia. Fruits eaten. Pittier, 1926. Garces, 1938.

Sarothamnus scoparius, Argentina. Leaves eaten by sheep and goats. Burkart, 1943a.

Schinopsis lorentzii, (quebracho colorado), Santiago del Estero, Argentina. Parodi, 1945c.

Schinus aroeira, (aroeira), Paraíba, Brazil. Barros, 1943.

Schinus latifolius, (molle), Chile. Opazo G., 1939.

Schizanthus pinnatus, Chile. Orellano O., 1943.

Sechium edule, (chuchú, chayote), Brazil ; Mexico ; Guatemala. Leaves may be used, chopped, either fresh or ensiled. Aguilar reports fruits and roots of value as feed for small animals. Pio Corrêa, 1931. Martinez, 1936. Aguilar G., 1943.

Senecio bonariensis, Uruguay. Herb. Eaten a little by animals. Rosengurt, 1943.

Sida rhombifolia, (escoba babosa), Venezuela ; (malvavisco), Uruguay. Perennial herb. Pittier, 1926. Rosengurt, 1943.

Silybum marianum, (cardo asnal), Uruguay. Annual, before flowering relished by animals. Rosengurt, 1943.

Simmondsia californica, (jojoba), Mexico. Leaves eaten. Seeds eaten by goats and wild animals. Martinez, 1936.

Sisyrinchium platense, (yerba del teru-tero), Uruguay. Herb. Only nibbled at by animals. Rosengurt, 1943.

- Soaresia nitida*, (oitica), Ceará, Brazil. Souza, 1943.
- Solanum auriculatum*, (couvetinga), Brazil; Uruguay. The leaves, which are rich in protein, are eaten. Pio Corrêa, 1931. Ramos de Otero, 1941, quoted by Rosengurt, 1943.
- Solanum bullatum*, (capoeira branca), Brazil. Leaves eaten. Good nutritive value. Pio Corrêa, 1926.
- Solanum cernuum*, (braço de preguiça), Brazil. Leaves eaten by cattle and rodents. Pio Corrêa, 1926.
- Solanum commersonii*, (papa cimarrona), Uruguay. Herb, eaten by animals. Rosengurt, 1943.
- Solanum verbascifolium*, Misiones, Argentina. Burkart, 1945a.
- Solidago chilensis*, (vara de oro), Uruguay. Herb, much eaten, chiefly by sheep. Rosengurt, 1943.
- Soliva sessilis*, Uruguay. Annual, much relished by sheep. Rosengurt, 1943.
- Sonchus asper*, (cerraça), Uruguay. Annual, much relished by animals. Rosengurt, 1943.
- Spartium junceum*, (retama), Cuzco, Peru. Young shoots eaten by horses, goats, sheep, llamas, etc. Herrera, 1930.
- Specularia perfoliata*, Uruguay. Annual, eaten by animals and disappears in heavily stocked places. Rosengurt, 1943.
- Sphacele lindleyi*, (salvia), Chile. Opazo G., 1939.
- Spigelia humboldtiana*, Uruguay. Herb. Eaten by animals. Rosengurt, 1943.
- Stachys arvensis*, Uruguay. Annual, eaten by cattle and disappears from grazed stubble fields. Rosengurt, 1943.
- Stenocalyx dysentericus*, (cagaiteira), Goyaz, Brazil. Leaves furnish excellent fodder; the fruits are also used as fodder before they are ripe. Pio Corrêa, 1926.
- Stenodrepanum bergii*, Argentina. Probably a forage plant. Burkart, 1943a.
- Stylosanthes*, 6 spp. in Argentina. Herbs, of some value as forage plants. Burkart, 1943a.
- Stylosanthes montevidensis*, Uruguay. Much-grazed herb. Rosengurt, 1943.
- Syagrus oleracea*, (coqueiro amargoso), Brazil. Palm. Leaves eaten. Pio Corrêa, 1931.
- Syagrus picrophylla*, (coco de quaresma), Brazil. Palm. Leaves and fruits eaten. Pio Corrêa, 1931.
- Tagetes minuta*, (coari bravo), Brazil. Herbaceous plant, considered a forage plant in Paraguay and in the Brazilian State of Matto Grosso, but in the State of Rio Grande do Sul it is considered a danger to grazing cattle. Pio Corrêa, 1931.
- Talguenea costata*, (talhuén, tralhuén), Chile. Opazo G., 1939.
- Telanthera polygonoides*, (quebra panella), Pernambuco, Brazil. Leaves eaten. Recommended for hay or silage. Fernandes e Silva, 1936.
- Teramnus uncinatus*, (faveira, amendoim de veados), Brazil. Araujo, 1935.
- Teramnus volubilis*, Brazil and Paraguay. Herb. Much forage value. Burkart, 1943a.
- Teucrium depressum*, Sonora, Mexico. Eaten by cattle. Gentry, 1942.
- Teucrium laevigatum*, Uruguay. Perennial herb, scarce, is eaten by animals. Rosengurt, 1943.
- Thalia geniculata*, (arumarana), Brazil. Leaves eaten by horses. Pio Corrêa, 1926.
- Thilao glaucocarpa*, (cipaúba), Paraíba, Brazil. Barros, 1943.
- Tipuana tipu*, (tipa), Salta, Argentina. Leaves eaten. Burkart, 1943a, 1945a.
- Traganum scariosum*, (curidinba), Brazil. Leaves eaten by cattle and horses. Pio Corrêa, 1931.
- Trema micranthum*, (crindíuva), Misiones, Argentina; Brazil. The leaves give good feed, especially for dairy cows; and the fruits are used for fattening domestic animals. Burkart, 1945a. Pio Corrêa, 1931.
- Trevoa trinervia*, (trevo, trevoa), Chile. Opazo G., 1939.

Trifolium polymorphum, (trébol del campo), Uruguay. Much-grazed perennial herb. Rosengurt, 1943.

Trixis hieracioides, Uruguay. Perennial herb, common, eaten by animals. Rosengurt, 1943.

Trophis americana, (ramón), Venezuela. Leaves give excellent feed for cattle. Pittier, 1926.

Ugni molinae, Magallanes, Chile. Opazo, 1939.

Vasconcellea chilensis, (= *Carica chilensis*), (palo gordo), Chile. Roots eaten. Opazo G., 1939.

Verbena erinoides, (yerba del incordio), Chile. Opazo G., 1939.

Verbena litoralis, Uruguay. Herb, common, kept short by cattle. Rosengurt, 1943.

Verbena tridens, (mata negra), Patagonia, Argentina. Davies, 1940.

Veronica arvensis, Uruguay. Small annual, apparently eaten by animals. Rosengurt, 1943.

Veronica peregrina, ssp. *xalapensis*, Uruguay. Annual, eaten by animals. Rosengurt, 1943.

Vicea linearifolia, Uruguay. Much-grazed annual, yields very little forage. Rosengurt, 1943.

Viguiera mandonii, (sunchu, huacso), Cuzco, Peru. Used as forage for cattle. Herrera, 1930.

Vouacapoua anthelmintica, (angelim de folha larga), Brazil. Pods eaten by cattle, but the rest of the plant is poisonous. Pio Corrêa, 1926.

Zizyphus joazeiro, (enjoa, etc.), Ceará, Pernambuco, Brazil. Leaves and fruits eaten. Fernandes e Silva, 1936. Domingues, 1941. Souza, 1943.

Zizyphus mistol, (mistol), Argentina. Fruits eaten. Burkart, 1945a.

Zornia diphylla, Argentina. Herb, good natural forage plant. Burkart, 1943a.

Zornia gracilis, Argentina. Herb, good natural forage plant. Burkart, 1943a.

Zornia latifolia, Argentina. Herb, good natural forage plant. Burkart, 1943a.

METHOD OF USE

The method of use varies considerably. In some, possibly in most cases, the shoots and leaves of the plant are cropped directly by the animal, which is thus able to exercise selection. In other cases branches and shoots are cut by the farmer, preferably in the early morning before the plant is "hot", and fed to stock. This form of use is an ancient custom in the State of Ceará, Brazil. (Souza, 1943.) Sometimes the shoots are chopped, as are those of *Cereus undatus* in Guatemala. (Aguilar, 1943.) In some cases it is the fruits that are used, either collected and fed to stock or picked up from the ground by animals. The fruits of *Caesalpinia melanocarpa* are eaten in this way by animals, especially by goats. (Castellanos, 1944.) Again, of some plants, for example, *Ipomoea arborescens* var. *glabra*, *Pithecolobium mexicanum*, and *Neoglaziovia variegata*, the flowers are eaten. (Gentry, 1942. Barros, 1943.) Finally, trees and shrubs furnish a type of natural hay in the dried, wind-borne leaves which have accumulated in depressions such as dry river-beds and ditches, where they form reserves to which cattle resort when every vestige of green leaf has disappeared. The entire absence of rain during the dry season protects such dried leaf reserves from mould. (Souza, 1943.)

NUTRITIVE VALUE

The nutritive value of such material varies still more greatly. Some plants, such as *Cordia oncocalyx*, *Mimosa caesalpiniiifolia* and *Zizyphus joazeiro*, are said to rival the best forage legumes in nutritive value. Others such as *Caesalpinia bracteosa* are valuable only on account of their early resuscitation. (Souza, 1943.) Some, again, are periodically toxic, such as *Pithecolobium auaremotemo*. (Alencar, 1941.)

There is a certain amount of information available on plants actually rejected by cattle, such as *Cassia laevigata*, a shrub found on the coast of the Province of Valparaiso, Chile. It is hoped in such cases to determine the principles which make them repulsive to animals and, once these are found, it is within the bounds of possibility that forms lacking these substances can be selected. (Elgueta, 1943.)

To the chemical composition of browse plants the scientific institutes are devoting an increasing amount of interest.

PROTECTION AND CULTIVATION

The protection and encouragement of trees and shrubs providing fodder is counselled by most agronomists. Souza goes a step further and urges that in north-eastern Brazil they should be cultivated and propagated and that a practice common in Cuba, Japan and Africa should be adopted, namely, the transformation of woody plants into herbaceous plants by means of continuous cutting. In Asia *Morus alba*, and *M. multicaulis* in particular, are planted closely (50 cm. $\times$ 50 cm.) and cut twice or even more frequently every year, so that eventually a meadowlike growth is obtained. In Cuba *Cassia siamea* is successfully cultivated in this way for green manure, and *Albizia lebbek*, which normally loses its leaves in the dry season (in Cuba, March and April), loses no leaves even in great drought when cultivated thus, nor does it undergo any period of rest. Souza considers that all the Ceará fodder trees, and especially the leafy legumes, could be similarly grown as herbaceous plants with great advantage to the animal industry. (Souza, 1943.)

An article by Medina urges the wider growing of *Prosopis juliflora* in Chile, especially in the northern deserts. The article is of general interest, but of special interest here also because the value of the tree's fruits as animal feed is recognized.

(Into one region of Chile the tree is said to have been introduced by herds of cattle which, fed on *Prosopis* fruits in Argentina and subsequently driven into Chile, disseminated the seeds in the latter country. The seeds have a protective capsule and are ejected unimpaired in the excreta. The trees were regarded first as weeds in the local lucerne cultures, but were subsequently cultivated for their own value.) The valuable part of the fruit is the pulp, which has an average fermentable sugar content of 62.7 per cent. Of 100 kg. fruit, 74 kg. consist of pulp having 45 kg. fermentable sugar and 26 kg. comprise seed and capsule. The following percentages are given for certain components of the pulp: protein or total nitrogen, 11.4; fat 4.26; starch 8.18; cellulose, 4.4. In Canchones, Chile, where the fruit is sold as fodder, it is used principally for mules and horses and is held to impart much energy, but it is also fed to draught oxen, fattening cattle, sheep, and some types of dairy cow. The Agronomic Station at Santiago gives the following percentages for digestible nutrients: protein, 9.1; fat 3.7; nitrogen-free extractives 65.1; cellulose 3.5. The coefficient of digestibility is 1/8.45. (Medina, 1941.)

OVERGRAZING

It is possible that the very vastness of the areas concerned in South America render somewhat less acute the danger of overgrazing browse and of the erosion which inevitably follows. At the same time, there are certain disastrous examples which it is well to bear in mind. Knoche, the South American climatologist, gave evidence in an Argentine journal to show that the Sahara Desert is not the product of a gradual desiccation, but has been developed through the action of man as a shepherd of goats in a region that was formerly covered with vegetation. The process is supposed to have begun in East Africa about 5000 B.C., terminating in the west about 4000 B.C. (Knoche, 1945.)

(ii) Poisonous plants

As has already been observed, nutritious and poisonous plants grow side by side. Steyn (1934, p. 53) speaks of "a sense of discrimination between edible and poisonous plants" in the grazing animal, but this sense is lacking in newly introduced, exotic animals and is lost in stable-fed animals and such as are brought up under unnatural conditions. Poisonous plants are therefore a

greater danger in South America at the present time, when the tendency everywhere is to improve existing stock by the introduction of superior, often European cattle, than they were to the scrub animal of colonial days. There are also other, well-known factors which may render poisonous plants especially dangerous, such as seasonal shortage of feed, overgrazing, dry conditions, and exhaustion in animals which have travelled long distances.

TOXICITY IN SORGHUMS

Information on the study of poisonous plants comes mainly from Argentina, Brazil and Uruguay. Of the plants studied the sorghums and especially Sudan grass, so widely grown as fodder, are naturally prominent. At La Estanzuela, Uruguay, over 40,000 individual plants of *Sorghum sudanense* are being studied for hydrocyanic acid content. (Boerger, 1940-41.)

An interesting fact that has come to light is the apparently increased toxicity of Sudan grass that has been exposed to attack by locusts. In 1932-33 Fernández studied pure sowings of Sudan grass in six different places for toxicity, which was found to be variable and a consequence of attack by locusts. In several places fatal results to cows are recorded, but none in the case of sheep, a fact attributed to their more selective manner of grazing. Although young shoots exhibit the highest degree of toxicity, no correlation between rainfall and increased toxicity was determined. On the other hand a definite relationship between soil texture and toxicity was found to exist, for the greater the quantity of soil colloids, the lower was the degree of toxicity, while there was a positive correlation between coarse sand and toxicity. (Fernández, 1933.)

Bonjour made a special study in 1933 of locust-attacked plants grown at the Agricultural College of San Antonio, Department of Salto, Uruguay. Toxic reaction was determined by the Guignard colorimetric process, and was greatest when fairly heavy rainfall succeeded the first cut. HCN content then fell, independent of temperature and rainfall, as a consequence of prolongation of growth, although it was always tender shoots which were studied. There was a negative correlation of 95 per cent between the colloid content of the soil and variation in the toxic reaction. Plants which had exhibited a low degree of toxicity were selfed and gave descendants in which toxic reaction was faint excepting in the first determination, made shortly after locust attack. In one plant there was no toxic reaction whatever, in spite of damage caused by locusts. Analysis of the experiments made at San Antonio has shown that the biological constitution of the individual plays almost as important a part as variability in climatic factors in causing varying HCN content. It is therefore possible to obtain non-toxic types by the progressive selection of seed parents, subsequently propagated by selfing. Before seed of non-toxic varieties is certified it should be tested for several years and exposed to locust attack, and after certification should be protected from the loss of its non-toxic character through adulteration or cross-fertilization. (Bonjour, 1934.)

In 1937 the same author, working at La Estanzuela, reported on further experiments made at that station, where breeding for varieties harmless to stock is in progress. Strains have been found which produce little HCN, and others in which the toxic principle is liberated slowly in the macerated shoots. Pasture experiments to determine whether there is any difference in the toxicity of these strains under field conditions are under way. Shoots of plants that thirteen days before had been cut by hand or had been close-cropped by locusts were tested for HCN. On an average the shoots of the plants levelled by locusts reached number 5 of the colour scale in the tests made with Guignard's picric acid paper, while sprouts of plants cut with the sickle averaged 1.8. All the plants were then cut down to the ground and after nine days (twenty-two days having elapsed since the withdrawal of the locusts) the sprouts were tested again for hydrocyanic acid. The plants on which the locusts had formerly fed even now remained somewhat more toxic. On an average they reached a Guignard test figure of 3.8, against 3.2 in the plants that had been

cut twice. The experiments thus support the opinion of stock farmers who have observed that after an invasion of locusts Sudan grass is apt to be more toxic than a crop normally mown or grazed. (Bonjour, 1937.)

Riet, Echenique and Sanz, of the University of Montevideo, have made tests of liquid taken from the stomachs of cattle that had just been killed, whence it is concluded that poisoning is due not so much to the amount of HCN present in the plant, but to the presence of factors in the animal organism which are capable of liberating HCN. Under normal conditions cattle are immune to the toxicity of Sudan grass, but the single or cumulative action of various factors may intervene to break down this natural organic defence. These factors include the diminution of alkalinity in the rumen and the reduction of salivation. The consumption of extremely tender and juicy herbage is accompanied by decreased salivation. Milking, especially in the case of heavy milkers, may render salivation difficult. (Riet and Echenique, 1936. Riet, Echenique and Sanz, 1937.) Costa's finding that Sudan grass pasture not only proved harmless to sheep but also tended to cure them of worm infestation has already been mentioned. (Costa, 1940.)

In Argentina, Giusti's studies of Sudan grass and other cyanogenetic plants are concerned rather with veterinary aspects of the problem. Nitrite and hyposulphite of sodium, injected, are found to constitute a powerful antidote. (Giusti, 1938.) Meanwhile the Government has published a warning to farmers that Sudan grass and sorghums generally are poisonous to animals when the plants are young and tender, and are especially dangerous when shooting afresh under rainfall after having suffered from drought or attack by locusts or other insects. Hail, frost, hurricane winds, etc., also tend to increase the toxicity of these plants. There is no danger to stock, however, if sorghums are fed when mature or ensiled. The symptoms of sorghum poisoning are described, with notes on treatment and preventive measures. The last-named include care in the choice of Sudan grass seed, which must be free of adulterants in the form of other sorghums or of poisonous plants. (Argentina, Dir. Ganad. 1941.)

For some further information on toxicity in sorghums see p. 157.

BACCHARIS AND CESTRUM

The Argentine Government publishes from time to time information for farmers on common poisonous plants, of which *Baccharis coridifolia* is a notable example. It is a shrub (Compositae) frequently found interspersed among the herbage of Argentine grazings, and is a source of great danger to hungry or tired cattle, especially during seasonal scarcity of herbage. Preventive measures suggested include the eradication of the shrub, and the curious native practice of "smoking" the cattle with fires composed of the dried shrub, a procedure said to create a repugnance for the plant in question. For indigenous stock such precautions are usually unnecessary, as *B. coridifolia* is generally avoided. (Argentina, Dir. Ganad. 1940.) Another plant of which the Government publishes an account is *Cestrum parqui* (Solanaceae). The symptoms produced by its ingestion are described and antidotes are indicated. The poisonous principle is an alkaloid which is active not only in the green parts of the plant, although these are generally the most dangerous, but also in the dried leaves: the dried stems are usually innocuous. (Argentina, Dir. Ganad. 1942.)

POISONOUS PLANTS OF ARGENTINA

In a recent publication Ratera lists the principal poisonous plants of Argentina which are—in addition to the two just mentioned: Leguminosae, *Astragalus unifolius*, *A. bergii*; Gramineae, *Lolium temulentum*, *Sorghum halepense*, *Stipa bomanii*, *S. leptostachya*; Caryophyllaceae, *Agrostemma githago*; Compositae, *Wedelia glauca*; Solanaceae, *Datura ferox*, *Nierembergia hippomanica*; Umbelliferae, *Conium maculatum*; Ranunculaceae, *Clematis hilarii*; Euphorbiaceae, *Euphorbia portulacoides*. Other species mentioned are *Xanthium cavanillesii* and *Oxyptelium solanoides*. Certain grasses are poisonous when attacked by fungi, as follows: *Paspalum*

dilatatum attacked by *Claviceps paspali*; *Poa*, *Lolium*, *Spartina*, *Hordeum*, etc., attacked by *Claviceps purpurea*; *Bromus catharticus* attacked by *Ustilago bromivora*; *Sporobolus poiretii* attacked by *Helminthosporium ravenellii*; *Festuca hieronymi* attacked by *Endoconidium tembladera*. The following species are suspect: *Solanum glaucum*, *S. elaeagnifolium*, *S. capsicastrum*, *S. pseudocapsicum*, *S. sisymbriifolium*, *Hymenoxys anthemoides*, and *Chloris distichophylla*. (Ratera, 1943.)

Rosenbusch and Zabala (1932) have studied the effects of *Claviceps paspali* on *Paspalum dilatatum* from the veterinary standpoint, and Giusti has published veterinary studies of two of the above-named plants, *Wedelia glauca* and *Astragalus bergii*, and also of the legume *Sesbania punicea*. The poisonous effect of *Wedelia glauca* is very variable, according to its stage of development and the species of animal concerned. In the case of *Astragalus bergii* the plant material was collected at various stages and from many parts of the Argentine Republic, and it is noted that the degree of toxicity was greater in lowland plants of luxuriant growth which had developed during rainy weather than in poor plants from higher altitudes grown under dry conditions. This is a phenomenon said to have been frequently observed in this plant. Of *Sesbania punicea* the seeds, which contain a cyanogenetic glucoside, are poisonous to birds and probably to other animals. (Giusti, 1935, 1938.) *Sesbania marginata*, which is abundant in some grazings, is probably also poisonous, as it is always observed to be untouched. (Burkart, 1943a, p. 301.) Some notes on poisonous plants of the Argentine monte will be found on p. 109. Parodi notes the hydrocyanic acid content of some upland species of *Stipa*, namely, *S. bomanii* and *S. saltensis*. (Parodi, 1946a.)

POISONOUS PLANTS OF BRAZIL

Poisonous plants are a serious trouble in the extensive grazings of Brazil often subject to conditions of drought. Among recent studies in that country the following may be mentioned.

Mello and Fernandes studied *Rhynchosia phaseoloides* (Leguminosae), *Hamelia patens* and *Palicourea nicotianifolia* (Rubiaceae), all plants hitherto reputed to be toxic, by means of feeding trials with guinea pigs, goats, and cows. The plants were found to be harmless. In the case of the first-named confusion possibly exists between the seeds and those of *Abrus precatorius*, which are very similar in appearance but extremely poisonous.

Heavy losses of stock in the State of Rio de Janeiro (Vassouras, near Sertão) were traced to poisoning by *Pseudocalymma elegans*, of the family Bignoniaceae. When fed to animals the plant is readily taken, for which reason its presence in grazings is very dangerous. An additional risk is that it is not well-known to graziers and has not even a popular name. The active principle is apparently an alkaloid or a mixture of alkaloid and glucosides. Experience has shown that lard and probably other fats, administered in time, have an antitoxic effect. (Mello and Fernandes, 1941.)

In the first of a series of articles to be published on the cyanogen-containing plants of Brazil, Machado and Occhioni have presented a study of *Tanaecium nocturnum*, a creeper of the family Bignoniaceae. The HCN content present in the distillate of the leaves (2-760 gm. per thousand) is found to be greater than any as yet determined in other Brazilian plants, including *Holocalyx glaziovii*. (V. Lucas, *Rev. Fl. Med. Rio de Janeiro*, 1941.) *T. nocturnum* contains cyanogen in all its organs and ranks among the poisonous plants. (Machado and Occhioni, 1943.)

Silva, at the Institute of Biology of São Paulo, Brazil, is studying poisonous and suspect plants of that state. Tests of the following plants on guinea pigs have proved all except four to be entirely non-toxic under the conditions of the experiments:

Rhynchosia lobata, *R. phaseoloides*, *Meibomia uncinata*, *Centrosema virginianum*, *Mimosa myriophylla*, *Baccharis tenuifolia*, *B. articulata*, *Serjania* sp., *S. cuspidata*, *Pleonotoma variabilis*, *Porophyllum ruderale*, an unidentified species and genus of the Sapindaceae (popular name "cipó farinha"); *Palicourea*

longepedunculata, *Psychotria florestana*, *P. capitata*, *P. leiocarpa*, *P. langsdorffiana*, *Euphorbia heterophylla*, *Bombax* sp., *Manihot* sp., *Ricinus communis*, *Erythroxylon deciduum*, *Cestrum sendtnerianum* and *Mascagnia pubiflora*. Of these plants, *Psychotria langsdorffiana*, *Erythroxylon deciduum* and *Cestrum sendtnerianum* are considered rather dangerous for stock feeding, while *Mascagnia pubiflora* was much less poisonous when administered to guinea pigs. From *Cestrum sendtnerianum* there was isolated in partially purified condition a saponin-like substance displaying powerful hemolytic and toxic properties. (Silva, 1943.)

POISONOUS ELEMENTS IN FEEDING STUFFS

Studies of feeding stuffs and miller's offals in Uruguay have revealed a considerable degree of impurity. Special attention is drawn to poisonous impurities represented by *Lolium temulentum* (the toxic quality of which is attributed to the presence of *Endoconidium temulentum* in the grain); *Agrostemma githago* (introduced in seed from Argentina, the seeds are toxic); and three other weeds of wheat fields, the seeds of which, while not directly toxic, exude in water a volatile oil productive of digestive disturbances. (Vedani and Bentancur, 1938.)

VICIA AND LATHYRUS

Fernandez and Echenique have investigated the poisoning of pigeons by the grain of *Vicia sativa*. These grains contain a glucoside which by the action of its own diastase and that of the pigeon's digestion duct is transformed into hydrocyanic acid, benzoic aldehyde and sugar. The influence of the *Vicia sativa* poison on cattle has also been proved. There is great confusion in different countries with regard to the names and the toxic qualities of *Vicia sativa*, *Lathyrus sativus*, and other leguminous plants in current use for animal feeding. The authors intend to make a methodical study of the seeds mentioned above in order to determine whether their use may be recommended unreservedly. (Fernandez and Echenique, 1939.)

Burkart has made a complete revision of the *Lathyrus* species of Argentina, the richest country in South America in regard to this plant, and at the same time of those of Uruguay, Brazil and Paraguay, but notes that there is no record of any study of the Argentine species for toxicity. (Burkart, 1935a.)

CHILE AND COSTA RICA

In Chile Mas y Guidal is studying cyanogen-containing plants (1941), and from that country comes a note of *Coriaria ruscifolia*, which is fatal to cattle and sheep although horses, goats and pigs are said to take it without injury. The effect is similar to that produced by strychnine. The plant is a small tree approximately 3 m. in height. (Santa Cruz, 1937.)

The Botany Section of the National Centre of Agriculture of Costa Rica is engaged in the study of the country's poisonous plants. (Orozco, 1939.)

(iii) Plants which impair the quality of meat or milk

In addition to plants that are actually poisonous, there are many which it is desirable to eradicate or suppress on account of the disagreeable flavour and even smell which they impart to the meat or milk, or both, of animals consuming them. Parodi has listed the following for Argentina: *Ambrosia tenuifolia*, found on the Pampa; *Artemisia verlotorum*, *Nothoscordum* sp., *Brodiaea uniflora*, *B. tweediana*, and others, found in the province of Buenos Aires; and *Mulinum spinosum*, found in Patagonia. Patagonian sheep reared in lands containing the last-named plant have to be transferred to another area for a month or more before slaughtering, in order that the disagreeable flavour imparted by *Mulinum* may be lost. (Parodi, 1945c.) One or two instances are given in the list of browse plants, pp. 165-77, namely, *Adenocalymma alliaceum* (Pio Corrêa, 1931), *Baccharis artemisioides* (Pio Corrêa, 1926), and *Erigeron bonariensis* (Rosengurt, 1943).

(iv) Weeds

The weed problem is discussed in Chapter 10, pp. 207-10.

CHAPTER 9

EROSION, GRASSLAND AND SOIL CONSERVATION

The Latin American countries have become keenly alive to the urgency of the erosion problem. The question is an international one, and inter-American discussions at the Eighth American Scientific Congress held at Washington in 1940 have thrown light upon South American difficulties. It is probable that most of the Latin American countries are affected. Bennett, of the United States' Soil Conservation Service, has published a general account of the problem and presents a broad estimate of the amount of land that is severely affected in the respective countries. It ranges from 50 to something over 60 per cent in some countries ; in others that have large areas of relatively smooth topography, such as Paraguay and the Guianas, damage has been relatively slight. (Bennett, 1945.) In Latin America itself the largest amount of information comes from Argentina, Brazil, Chile and Uruguay.

(i) Argentina

EXTENT OF EROSION

In Argentina the situation is grave, especially in the middle west region, where a heavy toll of the land has already been taken. In this region a large-scale destruction of the native woodlands and herbaceous cover of the plains has produced recurrent, serious droughts and an intensification of the velocity of the wind, and there has been an increased frequency of the cold south-west winds in the middle of summer. The arid climate natural to the western plains has advanced by way of the middle west, wedgelike, into the south, where the advancing desert threatens to overwhelm one of the best agricultural zones of the country. (See Fig. 15.) The amount of land affected is as follows :

Degree of erosion			Million hectares	Percentage of the agricultural land
Light to moderate	...	...	4.1	2.8
Moderate to severe	...	...	7.2	5.0
Severe to grave	...	...	4.6	3.2

From the Territory of Misiones also, situated between the rivers Uruguay (east) and Alto Paraná (west), serious erosion and land degradation is reported. The danger is probably still more widespread. Fiorda writes that erosion is proceeding south of the river Santa Cruz in Patagonia, where excessive grazing in many places is bringing about a denudation of the soil's protective plant cover. The evil here is as yet perceptible on a small scale only but is advancing more rapidly than is generally supposed, and it is believed that unless serious measures of control are taken the results may become disastrous at no very distant date. (Arena and Guiñazú, 1940. Arena, 1945. Davies, 1940. Gruener, 1941. Fiorda, 1940.)

The Government of Argentina takes a serious view of the problem, and efforts are being made to counteract the evil through surveys, experimentation and educational propaganda. The Institute of Soils and Agrotechnique of the Ministry of Agriculture, Buenos Aires, under the direction of A. Arena, is in charge of this work.

By the University of Buenos Aires a travelling laboratory is employed for soil survey purposes. (Paulsen, 1941.) At Miramar, on the coast of the province of Buenos Aires, there is a Dune Nursery where various plants are studied for their suitability for dune-binding and are propagated.

REGIONAL NATURE OF EROSION

The actual extent of this erosion, its causes and the resulting phenomena have been fairly fully described elsewhere. In every case, naturally, the amount of damage is closely related to the degree of resistance to erosion of the soil concerned. (*Herb. Abstr.* 1942a. *Aberystwyth, Bull. Imp. Bur. Pastures*, No. 32, 1944. Davies, 1940.) While these aspects are not within the scope of the present study, it may be noted that in the great middle west region wind erosion and

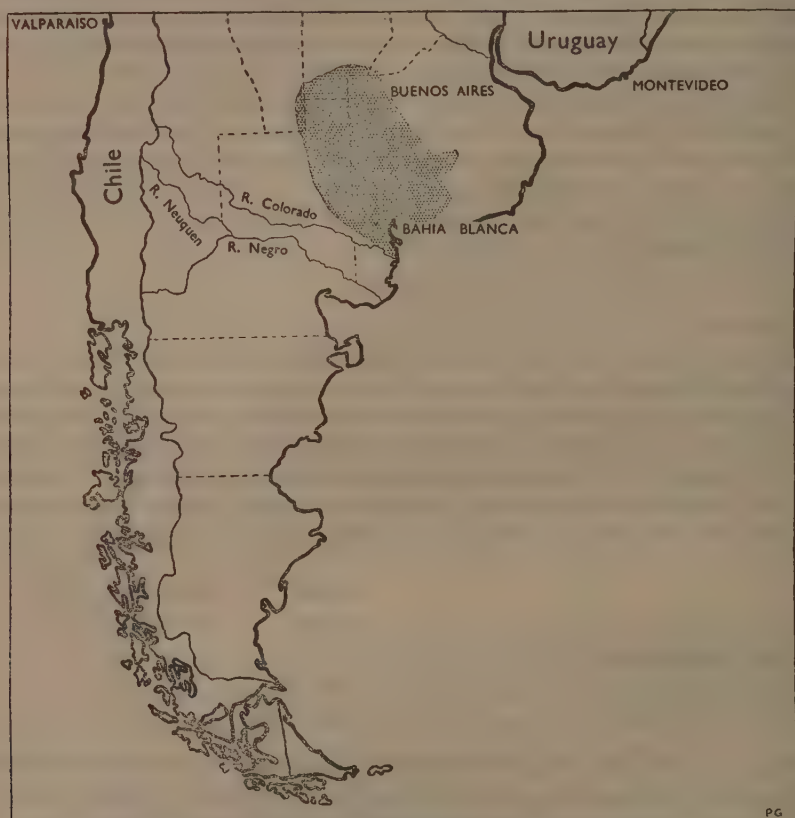


FIG. 15. WIND EROSION IN ARGENTINA. Adapted from Misc. Pub. No. 65. Ministry of Agriculture, Argentina. 1940

a consequent formation of shifting sand dunes is the principal trouble; in the province of Salta not only wind erosion but such as is caused by heavy rains and also by river flooding is present; in the territory of Misiones torrential rainfall is the main cause of erosion; in Patagonia both wind and the flooding that is caused by the thawing of the winter's snows appear to be concerned. Always, however, it has been the action of man which, in many different ways, has exposed the land to the destructive action of the natural agent operating, whether wind, water, or the force of gravity.

MEASURES OF CONTROL

"In the plant kingdom", writes Liebermann, "is the salvation that we seek." This author, in an article on erosion in the middle west, reviews the opinions of other writers on means of

control. Wernicke of San Luis counsels a widespread sowing of herbage and forage plants, especially rye. The Argentine Ministry of Agriculture is urging land owners and farmers to adopt—instead of continuous cultivation—rotational cropping; mixed farming; special care at sowing time; the cultivation of crops, such as lucerne, suitable for the zones menaced; tillage at propitious times; the ploughing-in of stubble; and special methods of sowing to avoid the excessive disturbance of soils. Alejandro V. Bergalli is particularly concerned with low and diminishing rainfall in the pampas and other parts of the country and is anxious to initiate afforestation on a large scale. His view is supported by reference to work done through afforestation by Miguel A. de Quevedo in Mexico, where the problem is said to resemble that of Argentina.

Liebermann notes in passing that the problem is partly of a social nature and is bound up with considerations of land tenure. (Liebermann, 1940.)

Wernicke has described successful co-operative action on the part of land owners and farmers as long ago as 1916, when the results of a severe drought were controlled through the sowing of rye and other forage plants as soil-binding agents. (Wernicke, 1940.)

Frigerio considers the trouble to be due principally to routine tillage by methods which, while suitable for rich soils under regular and abundant rainfall, are entirely unfit for the poor, 40 or 50 cm. deep soils and the low, irregular rainfall of the middle west region. This author stresses the value of stubble and weeds for conserving soil humidity and fertility, and describes machinery capable of performing tillage under a cover of vegetable debris (subsurface tillage) and a tooth harrow combined with a seed drill for working in the debris and sowing simultaneously. Lucerne can be sown under the cut weeds or stubble by means of the last-named implement. The machinery in question could not be imported from the United States under wartime conditions but was being studied with a view to its construction in Argentina. (Frigerio, 1944.)

For the province of Salta, Mintzer urges the following measures: (a) Wind erosion. Where in arid and semi-arid lands a water retention capacity of less than 18 per cent is determined and removal of the forest cover has rendered the area erodible, permanent grasslands should be established, composed of species such as lucerne, *Phalaris tuberosa*, *Chloris gayana* and *Pennisetum purpureum*, and care should be taken that they are not overgrazed. (b) Erosion caused by torrential rains. In this case the planting of *Acacia macracantha*, *A. cavenia* and *Flourensia riparia* is counselled, on the basis of experiments conducted by the Puerta de Diaz Experiment Station, and suitable technique is described. For the control of sheet erosion there are recommended cover crops of such plants as *Vicia faba*, *Melilotus alba*, and *Vicia villosa* as winter crops, and as summer crops *Vigna sinensis*, *Phaseolus*, *Stizolobium hassjoo*, *Stizolobium deeringianum* and *Glycine hispida*. (c) Erosion caused by river flooding. The construction of protective banks, etc., is recommended.

Incidentally, the following plant species are cited as indicators of poor land, unsuitable for arable farming: *Acacia cavenia*, *Caesalpinia praecox*, *Gourliea decorticans* and *Flourensia riparia*. The presence of a good proportion of *Prosopis*, on the other hand, indicates fertile land. (Mintzer, 1942.)

Arena and Guiñazú, who toured the middle west and reported on conditions there on behalf of the Government of Argentina, wrote that where the native vegetation—strips of woodland including *Prosopis caldenia* and other species of *Prosopis*, sporadic cacti, etc., and natural grassland—was undisturbed, there was no erosion. The picture of wind erosion that they drew was black, but at the same time they reported some successful efforts at control. In the Province of Córdoba, *Populus* spp. and *Arundo donax* are planted in some parts for the binding of moving sand. In the territory of La Pampa large areas of sand dune have been fixed by sowings of *Secale cereale* and especially by the indigenous *Plazia argentea* (Compositae) and the grasses *Stipa* and *Panicum*

urvilleanum. These fixed dunes, extending in the Utracan valley as far as the eye can reach, constitute excellent grazings in times of normal rainfall.

Human activities producing the middle west erosion comprise the destruction of forest and the ploughing up of the native grasslands, the tillage of arid land and the continuous growing of a single crop, overgrazing pastures, insufficient diversification of farming, and activities which bring about a falling of the water table. The last-named include an excessive growing of lucerne and other temporary leys, the continuous cultivation of a cereal or other crop plant, and the installation of a large number of wind-propelled water pumps and drinking-places for cattle, all of which have resulted in the impoverishment of the subterranean water reserves.

In these authors' opinion the principal point of attack should be the modification of the climatic conditions (rainfall, wind) through a large-scale plantation of trees in the denuded areas and the reafforestation of regions where ruthless felling of the native forest has taken place. It is considered probable that planting wind-breaks and shelter belts, so placed as to break the force of the south-west and north winds, would be most successful, and the following trees are recommended: eucalypts, especially *Eucalyptus viminalis* and *E. rostrata*; pines, especially *Pinus halepensis*; cypresses, especially *Cupressus lambertiana*; poplars, tamarisks, acacias, etc. The eucalypt is particularly suitable for tree belts to shelter cattle.

To the cultivation of the various native grasses and herbaceous plants especial importance is attached, the introduction of exotic species being considered to entail a risk of such species becoming unduly dominant. At the same time *Chloris gayana*, an introduced grass which is giving good results in the north of Argentina on account of its hardiness, is considered promising. It is the native grassland, however, which it is desirable to re-establish, wherein the species already mentioned, *Plazia argentea*, *Panicum urvilleanum* and the species of *Stipa* known as "puna" grass, are especially valuable. (Arena and Guiñazú, 1940.)

Arena, who is in charge of soil conservation research in Argentina, considers that the "severe to grave" areas should be withdrawn from all cultivation and used solely for stock raising (grass) and woodland; where erosion is less serious, subsurface tillage, strip and contour cropping and the alternation of cultivated crops with herbage leys for stock raising should take the place of monocultivation. Everywhere mixed farming should be the object, and a network of experiment stations is desirable. (Arena, 1945.)

SAND DUNE STABILIZATION

A considerable amount of attention is paid to the control of sand dunes in Argentina, and much success has been achieved in various parts. The use of *Populus* spp. and *Arundo donax* in the middle west has already been noted. At the Miramar Dune Research Station, created in 1937, there has been undertaken the consolidation of 600 hectares of shifting sand dunes, of which over 100 hectares may already be considered as reclaimed. Of the herbaceous plant species employed, preference has been given to the indigenous species, such as *Adesmia incana*, *Panicum racemosum*, *Plazia argentea*, etc., and to the exotic species *Ammophila arenaria* and *Mesembryanthemum edule* (?). (Moretti, 1939.)

In addition much work has been accomplished since 1936 in rendering certain beaches and other parts of the country accessible through the fixation of shifting sands by erecting stockades and planting trees. This work has been carried out by the Directorate of Agriculture of the Province of Buenos Aires. (M.A.N. July-Sept. 1943.)

Parodi has studied the Argentine sand dune vegetation not only *in situ*, but also in the botanic garden of the Faculty of Agricultural Botany, Buenos Aires (in plots simulating sand dune conditions), and at the Dune Nursery, Miramar, in comparison with introduced exotic

psammophytes. This author has published two lists enumerating respectively the native species of most importance as sand-binders, and those which may be grown in association with the former. The first list comprises the grasses *Sporobolus rigens*, *Panicum racemosum*, *P. urvilleanum*, *Spartina ciliata*, *Poa* (*Dioicopoa*) *lanuginosa*, and in addition *Plazia argentea* (belonging to the Compositae) and the legume *Adesmia incana*. Brief botanical descriptions and notes on distribution and cultivation are appended in each case. The second list names thirty-one species and includes many grasses and the legumes *Trifolium polymorphum* (creeping), *Lathyrus tomentosus* (caespitose), and *Lupinus multiflorus* (an annual). The last-named species would be of great value in improving sandy soils, always poor in nitrogen and organic matter. Further trial may necessitate the transference of some of the second list species to the first list of more important species. (Parodi, 1938e, 1939a.)

Pérez (1941) has called attention to the value of *Ammophila arenaria*, a grass foreign to Argentina, for dune consolidation. Moretti, again, of the Miramar Dune Research Station, has stressed the value of the sown herbage ley for the same purpose. (Moretti, 1941.)

EROSION IN MISIONES

Land degradation in the northern Territory of Misiones is considered by Gruener sufficiently important to compromise the whole regional economy unless measures of prevention and control are soon adopted. The landscape of the Territory is hilly, the watercourses numerous, having banks naturally stabilized by tree growth. The banks of the rivers Alto Paraná and Uruguay attain a height of 50 to 100 metres above the watercourses. The steeply sloping banks of these rivers are covered with very dense tree growth, but between the trees and the actual verge of the river there is an almost uniform, 30-metre-wide strip of *Bambusa guadua* which constitutes a perfect natural defence against the carrying off of the banks by rainfall or—to a certain degree—against erosion by the river when in flood. Typical of the territory are stony hills showing the bare rock in places, but having nevertheless covers of humus and organic detritus collected and protected by the hygrophilous forests, themselves characterized by greatly developed undergrowth. The vigorous growth of the vegetation in this humid, sub-tropical region is a weighty factor which almost entirely excludes the possibility of natural erosion in Misiones and can inhibit the phenomenon, once initiated, at the outset.

Erosion in Misiones is thus due to the removal of the plant cover through human activity; the principal natural factor bringing it about, however, is rainfall, which is of a torrential nature. The maximum intensity hitherto recorded is 75 mm. per hour, with a duration of two hours. This was at Loreto in the southern part of the Territory, and there is reason to assume the existence of still greater intensities in the heavier rainfall zones to the north. The human activities leading to erosion are the destruction of forest for shifting cultivation and for stock raising. The introduction of stock raising into the Territory is considered unfortunate; neither the climate nor the topography favour this industry, and the poor product that is obtained, together with the frequently burned and rapidly degenerating grazings, afford little economic justification for this form of land use. Even more serious as a cause of erosion is the clean cultivation of maté and other crops that is practised mainly by European settlers. Tillage and weeding, while perfect practices in other regions, are very dangerous under the conditions of Misiones. The large plantations of maté, the principal regional crop, are cultivated according to a uniform method, ploughed and harrowed in two directions whatever the contour of the land, often with devastating effects.

While deprecating the use of the natural forest land of this region for extensive, range grazing, Gruener expresses entire approbation of certain so-called artificial grasslands maintained by European colonists of Eldorado and other places for their own domestic animals. These meadows and

pastures fix the soil, are well managed, neither burned nor overstocked, and occupy only such areas as are strictly necessary. Grasses are sown or planted by means of slips, tillering species being chosen for preference. Of the grasses used, the following—indigenous in Misiones and the neighbouring regions—are mentioned: *Axonopus compressus*, *Cynodon dactylon*, *Paspalum dilatatum*, *P. notatum*, and *Stenotaphrum secundatum* together with its form *erecta*. (Gruener, 1941.)

(ii) Brazil

In Brazil, erosion and land exhaustion have become most prominent in the old coffee plantation lands, notably in the State of São Paulo. Here, as in the Argentine Territory of Misiones, heavy and often torrential rainfall is the chief cause of deterioration, but methods of cultivation have prepared the way for the action of rainfall.

EROSION IN SÃO PAULO

Senhor Fernando Costa, in 1940 Minister of Agriculture for Brazil, wrote in that year that when he was Secretary for Agriculture for the State of São Paulo he was impressed by the rapidly spreading degradation of lands employed as coffee plantations. The planters' custom was to use the land until production began to be reduced and then to move on elsewhere, leaving the derelict area a prey to erosive influences. This state of affairs was seen to begin in the State of Rio de Janeiro, and to proceed by the west of the State of São Paulo on to the State of Paraná. Senhor Costa initiated at that time an educational campaign among the planters of São Paulo, and introduced the practices of contour cropping, terracing, green manuring, etc. (*Bol. Min. Agric., Brazil*, 1940.) Now the State of São Paulo has a Division for the Control of Erosion and a large amount of experimental work is in progress in different localities. Accounts of this work have been given by H. V. de Camargo Bittencourt (1941 and 1943), and reviews have already been published (*Herb. Abstr.*, 1942e; and Aberystwyth, Imp. Bur. Pastures Bull. 32, 1944).

Experiments in control have been based partly on studies and a map of the State's soils made by the Agronomic Institute at Campinas. What is lacking, however, is exact information on critical rainfall. Information has been received of intensities of 100 and 107 mm. in one hour and of 54 mm. in 25 minutes. Nor can anything be said as yet on the frequency of the critical rains. In passing, it may be noted that in years to come this obstacle should be eliminated through the work of the network of ecological observation posts that is to be established throughout Brazil. These stations are to study the regional climates and soils in relation to plant production. (*Bol. Min. Agric., Brazil*, 1942a.)

MEASURES OF CONTROL

Of the various measures of control suggested by the State, strip-cropping as practised in the United States is not recommended for São Paulo, where peculiar difficulties are encountered. The essential point of this practice is the growing of strips of erosion-resistant, close-growing crops, preferably hay grasses and legumes, between strips of clean-tilled crops. Water and soil from the cultivated strips are held by the close-growing or meadow strips, variously named retention strips, buffer strips or correction strips. Of all the plants listed as used in the United States for this purpose only kudzu (*Pueraria thumbergiana*) could be grown at the same time as the crops ordinarily grown in São Paulo, and of the São Paulo annuals only rice and beans could be used for retention strips. But under the regional conditions rice cannot be grown successfully on a large scale except in flat land and irrigable terrains: its employment in the arid lands liable to erosion is hardly feasible. Beans, again, are a crop relatively little grown in São Paulo in comparison with cotton, maize, mandioca and castor-oil. There remains the possibility of making retention strips with a legume to be ploughed in eventually or with spontaneous vegetation. In both cases however,

the retention strips would generally have to occupy at least one-half of the cultivated land, and the present economic situation is such that no farmer could afford to sacrifice so large a potentially productive area, even for the sake of increased fertility. In addition, the planting of such an area with a legume would represent a considerable expense, while a retention strip of spontaneous vegetation would constitute a weed menace to the neighbouring cultures. Before strip-cropping on the North American pattern can be adopted, it will be necessary to find new crops at once economic, suitable for regional conditions, and having soil and water-retentive properties.

The growing of maize and cotton in alternate strips may be useful for the purpose of obtaining a rotation, but cannot furnish a solution to the erosion control problem.

Certain grasses have proved useful for the stabilization of cart tracks, canals, etc., in coffee plantations, namely, *Paspalum mandiocanum*, *Panicum maximum*, *Paspalum notatum*. Other plants that have been successful are *Vetiveria zizanioides*, *Cymbopogon schoenanthus* and *Calopogonium mucunoides*.

CONTROL IN COFFEE PLANTATIONS

As a rule coffee trees are planted in straight lines, the holes in which the trees stand being arranged—rectangularly. Generally a culture is laid out in large plots having approximately 5,000 trees, separated from one another by long, straight paths running at right angles to the slope. Methods of control that have been adopted by São Paulo planters are as follows :

1. Herbage. Herbage has been managed in different ways, namely, (a) cutting and collecting the crops in ridges running approximately across the slope of the land, between the rows of coffee trees ; (b) deferring cutting until the grasses are fully grown, when the mown crop is strewn over the whole surface of the ground ; (c) keeping the herbage cut short and preventing it from seeding, the ground remaining undisturbed ; (d) cutting in alternate rows, as far as possible, across the slope, so that the cut is taken from one-half of the area, while the herbage of the second half forms retention strips. It is considered that while (a) is to a certain degree useful in obstructing the run-off from heavy rainfall, it has the disadvantage of exposing large areas of land, bare and scraped, to the direct action of sun and rainfall. System (b) is fairly successful where the growth of the herbage is luxuriant and where the nature and slope of the land favour the control of erosion ; of the four systems described, it is perhaps the one most commonly used by the more progressive planters. System (c), while employed by some, entails much labour and also a competition between the herbage and the coffee plants, principally for water and especially in the dry seasons. System (d) has produced very good results in some especially hilly lands, but it has been little used as yet. It is considered worthy of careful experimental work. Although all these measures tend to lose their efficacy under extremely adverse circumstances, some of them can give satisfactory results under suitable local conditions.

2. Legumes. Intercropping with green manure plants has also been employed. The plants used for this purpose are *Canavalia ensiformis*, *Stizolobium deeringianum*, and sometimes *Crotalaria juncea*. It is considered difficult to determine their direct effect in protecting the soil from erosion. It is true that the organic matter with which they furnish the soil increases its water-absorption capacity and decreases its erodibility, and the plants themselves impede run-off and help to fix the soil, but as they have to be sown at the beginning of the rainy season if they are to compete with weeds and herbage, and as rainfall at this time is apt to be intense and frequent, insufficient protection is afforded the soil by the young legumes at a critical period. In addition, the mucuna bean (*Stizolobium deeringianum*), although valuable for its especially rapid growth, has the disadvantage of tending to climb the coffee trees.

3. Trenches. In some cases trenches are dug between the coffee plants and in the paths. These trenches are designed to collect rainfall to be subsequently absorbed by the ground. Those between the plants measure 1.20 m. by 40 cm. by 60 cm. and are situated across the slope ; those in paths and cart-tracks measure 1 metre in length, breadth and depth, and are dug at various intervals, the excavated earth being used to form a bank on the lower side. Such trenches are found to be a hindrance to agricultural operations and many of the ripening coffee berries fall into them and are lost. Under very heavy rainfall they overflow, the earthen banks are carried off and the trenches have to be remade.

4. Interlacing. A system at one time recommended from official sources is the so-called " permanent interlacing ", in which banks of earth and organic matter are constructed along all the paths between the rows of

coffee trees longitudinally and diagonally so that each coffee plant stands in the centre of its own quadrangle. This system was adopted by many planters but few retained it for long. One difficulty was the provision of sufficient organic matter for the construction of the banks. A disadvantage was the scraping away of the earth around the coffee plants for the same purpose, leaving the greater part of the ground bare and exposed to the direct action of the sun. What was perhaps the greatest disadvantage was revealed by examination of the coffee plants themselves, when it was found that immediately around the plants absorbent rootlets were rare or non-existent, while they were numerous and superficial in the banks. The coffee plant thus tends to develop an intense network of root hairs that are very superficial and much exposed to the action of prolonged droughts.

5. Small trenches. More recently the construction of small contour trenches, approximately 40 cm. in width and 50 to 60 cm. deep, has been tried. Their course in some cases is interrupted on approaching a coffee plant, the ends being closed for the retention of rainfall water; in other cases it is continuous, winding about among the trees and open at the ends so that the water discharges into the roads or cart-tracks. The edges are approximately level with the surface, excavated earth being deposited as a lateral bank on the lower side, but the spacing between the trenches is arbitrary and unrelated to the type of soil and slope of the ground. With the interrupted type, having the ends closed, spacing must be close in order to avoid overflow, and this makes construction more costly and forms a hindrance to agricultural operations. With the continuous type of trench there is more probability of the water running off, but in the course of the trenches among the coffee plants there are apt to be lower points which act as reservoirs, and the success of the system depends very much on the type of soil and the gradient, for the steeper the land, the greater are the difficulties. In the construction of these trenches, also, insufficient consideration has been given to provision for run-off.

6. Contour furrows and ridges. The last system discussed is that of contour furrows and ridges, used principally by planters in the municipality of Jaú. These are distinguished from the contour trenches just described by being flat and wide (approximately 1 metre, whatever the soil or gradient) and by being accompanied by low ridges. Where this system has been used no signs of erosion are to be seen. When ridges have been destroyed at certain points by heavy rainfall, this has been due either to the fact that the extremities of the furrows have been closed up, or—in many cases—that they have received the water of the cart-tracks. Many planters keep their cart-tracks sodded with *Stenotaphrum secundatum* with most satisfactory results, and where this is done there is no overcharging of the contour furrows with run-off from the roads. The position is still better when the contour furrows have their extremities opening into sodded roads or cart-tracks. (Bittencourt, 1941, 1943.)

An account of combined contour ridging and terracing carried out on an estate belonging to the Campinas Institute of Agronomy, State of São Paulo, has been given by Cuba. A rectangular frame, standing on two feet approximately two or four metres apart (in the case of coffee and cereals respectively) carried the level. Results were entirely satisfactory. Incidental to the improvement of the plantations is that of the roads also, for the contour ridges are so arranged that excess rainfall in the roads runs off into the extremities of the ridges. (Cuba, 1937.)

PROSPECTS IN SÃO PAULO

Dr. Fernando Costa, the initiator of soil conservation in São Paulo, has toured that State recently and is now optimistic on the future prospects of its agriculture. He concludes that there is no absolutely fatigued or exhausted land. The diminishing productivity of the older lands—which certainly becomes increasingly apparent—can be arrested by the application of scientific agricultural measures which would also ensure the obtaining of products entirely satisfactory both in quantity and quality. For the promotion of scientific agricultural practice Schools of Agriculture, having both educational and experimental aims, are being established in the different agricultural centres of the State. In the meanwhile the newer lands, for example, Alta Sorocabana, reveal an amazing degree of fertility. (Costa, 1943.)

EROSION IN MINAS GERAIS

A warning note from the mining regions of the Brazilian State of Minas Gerais is uttered by Giesbrecht. In connexion with the establishment of iron works in the fertile valley of the Rio Doce, huge tracts of virgin forest are to be destroyed, the wood being required for fuel. The processes (rapid under tropical conditions) leading from deforestation to soil sterility and finally

erosion are outlined and illustrated by occurrences in Japan, U.S.S.R. and the United States, and the author give a warning of the serious consequences to be expected unless steps are taken to enforce measures of soil conservation such as reforestation. Already the practice of burning to obtain cheap grazings has been responsible, among other causes, for reducing to less than one-half the area under forest in the central valley of the Rio Doce and in the valleys of the Mucury and its tributaries. Instances of deforestation in other parts of the country are cited. (Giesbrecht, 1936.)

NORTH-EASTERN BRAZIL

A report by Gehlsen on measures to control drought and soil erosion in north-eastern Brazil deals less with erosion than with the climate, social conditions of the region, Government and co-operative action in the construction of reservoirs, well boring, irrigation, improvement of the road system, and propaganda and information service, on all of which subjects much information is presented. (Gehlsen, 1941.) In the present Bulletin the climatic conditions of this region have already been discussed in Chapter 5 (b).

(iii) Uruguay

EXTENT

Erosion has not yet assumed very serious proportions in the undulating grasslands of Uruguay, and the watercourses of that country have for the most part a natural protection of woodland growth. Nevertheless an increasing amount both of actual erosion and of soil deterioration is evident. According to the Director of the Forest Service, the Department of Canelones alone has over 100,000 hectares of eroded and abandoned land. (Vera, 1945.) Over-exploitation in certain parts and the cultivation of unsuitable, especially sloping lands have led to a deterioration of soil fertility in many places and to the appearance of bleached patches of degraded land known as "blanqueales" or "white patches", from which leaching has removed all organic substance, leaving a sandy, greyish sterile soil. It is possible to distinguish these patches, when not cultivated for over ten years, by their natural flora, consisting of poorer species and producing less herbage (430 gm. per m²), while the adjacent normal soil bears a flora similar to that of good pastures with a higher herbaceous yield (1430 gm. per m²). (Garmendia, 1940. Arena, Bentancur and Ribeiro, 1940-41.) Quinteros, Arocena and Vercesi consider that the practice of periodic burning has played an important part in causing erosion and soil degradation in Uruguay. (Quinteros, Arocena and Vercesi, 1939, quoted by Boerger, 1943.)

CONTROL

Where bleached areas are not absolutely beyond reclamation, organic fertilizers, whether farm-yard manure or a legume used as green manure, may be successful in restoring a certain amount of fertility. *Melilotus alba* is dear on account of seed scarcity, and seed procured at Buenos Aires gave poor results when tried in such land, although the indigenous *M. parviflora* is said to thrive fairly well in it. Spangenberg tested different varieties of lucerne in degraded land of this nature and found Peruvian varieties, especially "Omas", more suitable for the purpose than others. This method of reclamation can only be used where the land is of a clayey constitution and has at least 12 to 16 per thousand humus. In poorer land (7-8 thousand humus) lucerne has failed. (Spangenberg, 1937.) Garmendia has experimented in the growing of *Pennisetum purpureum* and *Sorghum sudanense* in these lands. (Garmendia, 1940.)

Vera reports on the use of trees such as *Acacia cyanophylla*, *Populus nigra*, *P. alba*, *Eucalyptus* spp., *Salix alba* var. *caerulea*, *S. babylonica*, *S. viminalis*, and (for salt lands) *Tamarix gallica*, for the control of various forms of erosion. Under some circumstances *Arundo donax*, *Bambusa arundinacea*, *Guadua angustifolia* and other grasses are planted. (Vera, 1945.)

WEEDS AND FERTILITY

Bonjour, studying weed growth in a crop rotation experiment in progress at La Estanzuela from 1917 onwards, has touched on the relation of tillage and weed control to erosion. Weeds are regarded as a major factor in the deterioration of soil fertility in over-exploited lands. (Bonjour, 1935.)

SAND DUNE AND MARSH RECLAMATION

Some interesting work in marsh reclamation and in the control of shifting sand dunes by means of afforestation has been done in Uruguay.

In 1940 Caldevilla gave an account of the draining of the Carrasco Marshes, which occupy an area of 1,142 hectares at a distance of 17 kilometres from the city of Montevideo. Even when dry, they are uninhabitable and of negligible value for grazing; and from March to November, when they are inundated, they constitute a mosquito-infested menace to the adjacent capital. Their drainage and reclamation, by means of canalization and the systematic planting of willows, poplars, eucalyptus and other trees, had then been in progress for two years at the order of the Ministry of Public Works, the planning and direction being in the charge of Miguel Quinteros, Jr., Professor of Forestry in the University of Montevideo. In Caldevilla's article a full account is given of the Marshes themselves, of the adjoining National Park, which has been reclaimed by afforestation from shifting sand dunes, of the plan and technique of the work and of the results already achieved. The annotated list of plants includes fifty-six grasses and nine legumes. In the area already reclaimed a marked change in the natural vegetation is apparent: *Scirpus riparius* and *Typha domingensis*, which are dominant in the undrained marsh, have receded before *Echinochloa crus-galli*, and an association has been formed which is described as transitional between meadow and dune on the one hand and marsh on the other. The new land is eagerly sought by roaming herds of cattle, so that the young tree nurseries for which it is employed have to be fenced against them. (Caldevilla, 1940. *Herbage Abstracts*, 1941.)

Reclamation of the national reserve named the Uruguayan Centenary Park began in 1916, and the planting of exotic forest trees has led to the fixation of 350 hectares of dunes formerly wind-blown. Rosa-Mato and Caldevilla have published a botanical study of this area which contains also notes on the grasses present. In the moving dunes are recorded *Spartina ciliata* and *Andropogon bicornis*, which are dominant. *Panicum racemosum*, normally found in such associations, is absent in the moving dunes but in the depressions is dominant together with *Spartina ciliata*, and is accompanied by *Poa lanigera*, some Cyperaceae and other species. In the shelter of the fixed dunes a much richer type of vegetation is found, containing, among other species listed, twenty-four different grass species and four legumes. (Rosa-Mato and Caldevilla, 1939.)

RESEARCH

The general study of erosion and methods of control and soil conservation in Uruguay is in charge of the National Commission for the Study of the Forage Problem. Already a soil survey of representative areas of the whole country has been made and much valuable information collated. (See p. 47.) (Boerger, 1939b).

(iv) Chile

EXTENT

Erosion in Chile is a problem of great magnitude. Its extent has been outlined by Guérin in an address to the Eighth American Science Congress and in a broadcast, both delivered in Washington in 1940. The problem is most serious in the humid zone of the south. Gully and sheet erosion are the usual types. Wind erosion, however, is practically unknown, although there are

some small areas of dunes where the Government is carrying out afforestation schemes. Four factors affect the position, (a) rainfall, (b) rivers, (c) topography and soil, and (d) agricultural technique. Guérin's findings have already been reviewed at some length elsewhere (*Herb. Abstr.*, 1943) and only a short summary can be attempted here.

(a) Rainfall. The narrow, three-thousand-mile long strip of land that is Chile has a rainfall varying enormously with the latitude from north to south. The north has an arid region with no rains at all, in central Chile rainfall ranges from 12 to 30 inches (304.8 to 762 mm.) ; in the southern, humid region it rains from 40 to 100 inches (1016 to 2540 mm.) or more in a year. Characteristic is a division into dry and rainy months : at approximately lat. 38° 47'S. and even farther south there are periods of drought lasting for a month and more, when the temperature is 30° C. and over.

(b) Rivers. The rivers of northern Chile are of a torrential and turbid nature. They rise in the Andean snows and become torrential when the snows melt and during the rainy season, but have a minimal water volume in the dry season. Preliminary studies of sedimentation have shown them to carry off enormous quantities of matter. Silting often presents a serious problem, but at the same time valuable soils have been formed in what were previously barren wastes.

(c) Topography and soil. Practically the whole contour of Chile is undulating or of broken outline ; the arid north has especially rugged lands. There are no large level areas, and such plains as exist always have a gradient of over 3 to 4 per cent, so that the run-off of water is rapid. The soils of the semi-arid zone are entirely alluvial, with a general deficiency of lime, potassium and phosphorus ; those of the humid zone are of volcanic origin and are characterized by acidity.

(d) Agricultural technique. Where erosion is most serious, namely, in the humid southern zone and especially in the Provinces of Malleco and Cautín, agriculture was not begun until the second half of the nineteenth century, when the natural cover of forest was burned and an exclusive wheat-fallow cropping system was adopted. In Malleco 3,200 hectares were under cultivation in 1876, by 1940 the area had increased to 80,000 hectares. In a period of not more than sixty years there has been created one of the gravest problems of erosion known. The fallows on the undulating lands were exposed to the action of the weather and to-day wide areas are totally denuded of the top, humus soil, leaving a subsoil of volcanic origin with a pH of approximately 5.5. Wheat yields are poor and only obtainable by means of fertilizers.

In marked contrast to Malleco and Cautín is the more southerly province of Osorno, where animal husbandry has been developed and wheat is alternated with four-year or older herbage leys. Although the present leys might be greatly improved, consisting as they do almost exclusively of *Dactylis glomerata*, *Holcus lanatus* and *Arrhenatherum elatius*, their interpolation has sufficed to produce high yields of wheat.

EROSION IN THE DIFFERENT REGIONS

In the central zone erosion is less pronounced, its effects being seen mainly in the mountain slopes denuded of vegetation and in the undulating dry lands. The prolonged dry season necessitates the use of irrigation for most of the crops grown in this zone, and the irrigation is relied on to leave sediments. Although the process is usually faulty, with excessive gradients, the irrigation waters generally leave more sediment than they carry off. In the irrigated lands with a varied form of agriculture including a rotation of food crops, cereals and herbage, erosion is not serious ; but it is otherwise with the dry, coastal lands. They are undulating, and the cropping technique employed is a rotation of bare fallow and wheat and grazing by small animals. All vegetation dries up in the summer. The wheat grown in much of this land, even in cases of pronounced slope, always follows a bare fallow begun with the first rains of the previous rainy season. It can be understood that land of this nature, tilled in the middle of winter in a period of fairly heavy rainfall, since all the annual precipitation is concentrated at this epoch, suffers seriously under gully and sheet erosion. Great gullies are characteristic of the coastal slopes.

HERBAGE AS CONTROL

Such is the Chilean problem, and the authorities are now engaged in studying means of control. Guérin notes that afforestation is not easy, in the arid and semi-arid zone on account of the pro-

longed periods of dry weather, and even in the humid zone on account of imperfect knowledge as to the appropriate species, the indigenous trees being in general of slow growth. In this author's opinion the development of herbage growing is of great importance for the control of erosion, while incidentally it would help to solve the country's present meat shortage problem.

Preliminary work in this direction is already in progress, carried out by the Ministry of Agriculture's Department of Genetics and by the Experiment Station of the National Society of Agriculture. The latter Station is studying, for example, the natural flora of the coastal area between the river Mataquito (34° - 36° S.) and the town of La Ligua (32° $38'$ S.).

The importance of herbaceous swards for soil conservation is realized, and at ten centres in different parts of the country the Department of Genetics is testing, acclimatizing and reproducing productive herbage plants. Two of these centres are situated in regions where disastrous erosion has taken place, namely, Cauquenes in the Province of Maule and Collipulli in the Province of Malleco, and the wide dissemination of species found successful in Chile is contemplated. (Guerín, 1941, 1942. Jirkal, 1942.)

Over 150 hectares were devoted to herbage seed production in 1943, and at present the following species are being reproduced for distribution: *Poterium sanguisorba*, *Phalaris tuberosa*, *Ornithopus sativus*, *Lolium perenne*, *L. italicum*, *Bromus arvensis*, *Trifolium repens*, *T. incarnatum* and *Lotus uliginosus*. (See pp. 71 and 237. Elgueta G., 1943, 1944.)

Alarcón has suggested that the creation and organization of a Department of Soils under the Ministry of Agriculture is necessary, together with the establishment of an Agricultural Bank to supply credits for the control and prevention of erosion. (Alarcón, 1942.)

(v) Ecuador

EXTENT OF EROSION

As in Chile, rainfall is the chief natural agent of accelerated soil erosion in Ecuador. The Director General of Agriculture in that country has recently given an account of the position there. (Ordeñana, 1942a.) Of the three broadly defined zones which comprise Ecuador, one, the eastern Amazonian region with its practically untouched cover of luxuriant, primeval forest, as yet little exploited, can be left out of consideration except so far as the desirability of introducing rational methods of land use from the very outset may be stressed. The littoral zone, however, rising from the Pacific to approximately 800 metres and composed of rich alluvial soils, and the high inter-Andean zone, rainy in most parts, excessively dry in others, and used generally for an intensive form of agriculture, often under irrigation, have both exhibited disquieting phenomena which call for measures of control and conservation. In each of the two threatened zones some 70 million hectares of valuable land are concerned.

THE LITTORAL

The littoral produces almost the whole of Ecuador's export crops, together with some other commodities consumed at home. In the flat part of the region, the spontaneous and luxuriant forest vegetation and the permanent cultures to a certain extent protect the land against erosion and run-off, but the land that has been deforested in order to make room for cultures suffers the direct action of the sun's rays and injury from the copious rainfall, which carries off the mineral elements to the rivers. To this is added the injurious effect of the custom, general and inveterate, of burning all debris and vegetable matter on land that is being prepared for sowing. This method, almost indispensable under local conditions, nevertheless causes a destruction of organic reserves, impoverishes nitrogen content, and changes the whole colloidal and biological nature of the soil. In the coastal lands of Ecuador, with rare exceptions, no manures or fertilizers are used.

The rooted habit prevails of abandoning land after one or two annual crops have been taken and returning to it again in two or three years. The cultivated fallow system and any rational rotation of crops are unknown, nor are cover crops interpolated between the permanent crops, all of which practices might be used as methods of soil conservation. The coastal lands of Ecuador thus present, through their climate and soil, a fount of riches which would be inexhaustible if modern, scientific systems of conservation were extensively employed.

THE INTER-ANDEAN ZONE

In the interior, inter-Andean zone a relatively hot temperature is found in valleys up to an altitude of 1,200 metres, suitable for growing tropical and sub-tropical crops. At a greater height and up to 3,800 metres the cereals of temperate climates and other commodities are grown and the principal animal industry region is found. Still higher are the mountain grazings of llamas, alpacas and sheep. Crops are nearly always grown under irrigation, which is easy to instal thanks to the topography and the innumerable waterfalls and streams which intersect the region. The soil is of volcanic origin and mineral content varies greatly in accordance with locality. In many cases organic matter is rare. The same problem of erosion from rainfall is encountered as in the littoral, with the aggravating circumstance here of topography and slope. The carrying away of earth is therefore more intense than in the littoral and in some regions of friable soils is very marked.

AGRICULTURAL TECHNIQUE AND CONTROL

To control it the farmers use plants such as a species of *Agave* (black sisal), a species of *Fourcroya* (white sisal), *Gynierium sagittatum*, *Spartium junceum*, *Arundo donax*, various species of the Gramineae, etc., but the use of these plants should be better studied and made known. In the crop-growing of this region organic manure is generally used and the land is sometimes limed, although imperfectly. Chemical manures are not systematically used, but the more progressive farmers practise a rotation of crops by interchanging potato, cereals, and an indigenous species of lupin. The lupin is not ploughed in, however, but used as a vegetable for human consumption. Tillage is in general superficial and done with rudimentary types of plough, but the large estates are introducing the tractor and modern implements. Drainage here, as in the littoral, is often necessary in order to improve the quality of the land and to prevent animal diseases caused by internal parasites.

The tendency of agriculture in the inter-Andean region is always to be intensive, and holdings are more fragmented than in the littoral, where agriculture is of an extensive nature. This, perhaps, may be an advantage for the higher zone, facilitating the adoption of scientific methods of cultivation and soil conservation.

Finally, the reforestation of the inter-Andean zone should be included in any rational agrarian policy, wherein the growing of conifers is of importance, for the woodlands of the Sierra are very sparse and comprised mainly of eucalypts, with a few conifers. (Ordeñana, 1942a.)

(vi) Guatemala, Colombia, Mexico, Cuba, Venezuela

GUATEMALA

At the Eighth American Science Congress in 1940 Herrarte, the Director General of Agriculture for Guatemala, enumerated the causes of erosion in that country and suggested means of control. The latter included the use of cover plants, reafforestation and forest protection, prohibition of cultivation of erodible lands, and a general improvement of agricultural technique, wherein crop rotation is noted as preventive of land impoverishment. (Herrarte, 1942.) Klein has outlined methods of conservation in the Guatemalan Government's agricultural journal. Under the tropical conditions of the country it is imperative that not for a single hour should the soil be

denuded of a close plant cover, and herein the important part to be played by the legumes and the necessity for rotational cropping are emphasized. (Klein, 1941.) Deger, of the same country, has stressed the urgency of maintaining the humus content of tropical soils by growing legumes and green manure crops and by alternating annual or biennial cultures with five to eight-year crops such as cotton. (Deger, 1942.) Recently some alarming photographs of erosion in south-eastern Guatemala have been published by Arrivillaga, who deplores up and down ploughing, describes contour cropping as the only safe means of cultivating hillsides, recommends herbage and forage plants, especially *Pennisetum clandestinum* and *Pueraria thunbergiana*, for impeding run-off, and finally gives an interesting account of river bank reclamation as practised on a Guatemalan estate. The river in question had carried off enormous quantities of earth, leaving "deserts of stones and boulders" behind. Dams were constructed and the waters of the river forced up into artificial canals with slopes of 1 per cent or even less. Pará grass (*Panicum purpurascens*) and Napier grass (*Pennisetum purpureum*) were sown between the stones and watered slowly from the canals. The canal water carried humus earth in suspension, which is now accumulating among the grasses at the rate, it is said, of several inches annually. In place of the stony wastes there are now useful grasslands which are cut every six weeks and can maintain eight to ten animals per hectare. (Arrivillaga, 1945.)

COLOMBIA

There is not much direct evidence from Colombia, but it is clear that the problem is not unknown to that country. When a Commission consisting of a phytopathologist and an entomologist was appointed to investigate the decay of the onion-growing industry of the mountain Province of Ocaña or Santander del Norte, it included in its report a certain amount of information on soil erosion in that Province and made suggestions for its control. Eroded regions having a slope of from 30 to 40 per cent, at present almost abandoned, should be grassed and used for stock raising. Grasses suitable would be *Pennisetum clandestinum* and *Melinis minutiflora*. Eroded lands having a slope not exceeding 20 per cent should be used for carefully planned rotations including *Medicago sativa* or other leguminous, soil-improving crops. (Botero and Otoya, 1941.)

MEXICO

Patiño stated at the Sixth Pacific Scientific Congress that erosion is one of the most serious problems the Mexican Government has to deal with, and he made a plea for inter-American co-operation in the study of American erosion problems generally. (Patiño, 1940.) Bennett has written that erosion in Mexico is mostly a local problem, but in some parts large areas have suffered severe damage. Extensive overgrazing has led not only to the rains taking a toll of the uplands, but to floodwaters damaging portions of the alluvial plains. In dry upland valleys, overgrazing has exposed much land to wind erosion. The rapid extension of irrigation, further, leads to the necessity of measures for controlling technique and forestalling destructive erosion. It is believed that the Government is developing a programme for the control of erosion. (Bennett, 1942.)

CUBA

In Cuba, although the problem of erosion is felt throughout its undulating lands, it is gravest in those occupied by tobacco. A study by Pérez of its causes leads to the conclusions that the present systems of preparatory tillage should undergo certain modifications, and that measures for increasing the soil's content of organic matter should be taken. Certain customs also should be suppressed, especially that of allowing animals to graze the natural herbage which appears in tobacco fields in the spring and summer.

Experiments in the use of herbage and legume crops for restoring soil fertility and preventing erosion have been made at the Experiment Station for Tobacco Cultivation, San Juan and Martinez, Province of Pinar de Rio, Cuba.

If allowed to develop and left ungrazed, natural herbage grows with great luxuriance under the effect of such chemical fertilizers as have not been entirely utilized by the tobacco, and can produce as much as 45 tons green weight per hectare. Its benefit to the tobacco field consists in the fixing of the soil and in the provision of organic matter.

An experiment was made at the Station in 1937 to test the value of natural herbage and other rapidly-growing plants for the obtaining of vegetable matter and for covering the field as quickly as possible. The herbage in this case consisted chiefly of *Dactyloctenium aegyptium*, *Parthenium hysterophorus*, *Amaranthus spinosus*, *Cassia tora* and *C. occidentalis*, and occupied one 5,000 sq. metre plot, four more being sown with *Stizolobium deeringianum*, *Glycine hispida*, *Zea mays*, and *Avena sativa* respectively, while a sixth plot was left fallow. As each plot reached its maximum development the crop was cut and ploughed in. The green weight obtained per hectare was as follows, in kg.: natural herbage 30,210; *Stizolobium deeringianum* 20,880; *Glycine hispida* 13,590; *Zea mays* 35,720; *Avena sativa*, nil.

The velvet bean rapidly covered the ground, but its yield of green weight was small. Its stems and leaves are found to be very rich in water and the organic matter is readily decomposed and of short duration in the soil under the moist and hot climatic conditions of Cuba. Unless suitable machinery is available its interment is expensive, as it has to be chopped with a machete before it can be ploughed in. The soybean had a great quantity of root nodules; its development was rapid, but it did not grow to any appreciable height nor did it succeed in covering the ground, so that much soil was left exposed to eroding influences. The maize soon covered the field and reached a good height, and although it was of rapid development and the first to be ploughed in, the stems were not entirely decomposed when the tobacco was sown. The oats hardly attained a height of 10 in. (25.4 cm.) and then died.

The natural herbage grew to a height of 1-10 to 1-20 metres in some parts, the field was rapidly covered and it was possible to plough it in without preliminary cutting. It had some other advantages over the other plants; it was, for example, the cheapest, for although the maize yielded 6.5 tons green weight per hectare more than the herbage it cost much more to produce. The value of the herbage for cover also was greater than that of the maize, the crop most nearly approaching it, because the maize had to be ploughed in one month before the herbage and because while the ground was furrowed regularly under the maize, under the herbage the surface was irregular and thus less erodible.

Although the advantages of natural herbage as a preventive of erosion are obvious, of all the customs rooted in Cuban agriculture the most difficult to eradicate is that of grazing cattle in the tobacco fields.

For this reason, and with a view also to preventing the invasion of light sandy lands by nematodes, the Station made a trial of eight species and varieties of *Crotalaria* supplied by the United States Department of Agriculture, in comparison with a late variety of *Crotalaria spectabilis* and with *Stizolobium deeringianum*. They were tested for their value in flat or slightly inclined lands of medium fertility. (It is considered prejudicial to sow legumes or any other plant in markedly inclined lands in Cuba: such land is usually deficient in fertility, and plants sown in spring do not succeed in covering the ground before the torrential rains come and carry off the exposed soil. Nor is the yield of green matter sufficient to cover the costs of production.) Three of the American varieties, belonging to the species *Crotalaria spectabilis*, *C. striata* and *C. usaramoensis*, gave satisfactory results, and they are being tested further for their value as sources of organic matter as well as for their effect on tobacco quality and in the control of nematodes. (Pérez, 1942.)

VENEZUELA

In Venezuela long years of growing wheat and maize in erodible soils and on slopes having often an inclination of over 50 per cent, the destruction of forest, overgrazing, and voracious grazing by goats have produced gully erosion of the most alarming type in many of the hill lands. Public

works such as the trans-Andean highway and the aqueduct of Valera are imperilled ; a bridge uniting two towns in the State of Tachira has actually been destroyed by a river whose flooding was augmented through erosion. In the last-named case tree felling on the slopes was the immediate cause of erosion.

A Soil Conservation Service has now been established in Venezuela. Among the initial work there may be mentioned a trial of different legumes for the reclamation of seriously eroded wheat lands in the Andean regions that was initiated in 1944.

A preliminary report states that of the twenty-five species sown only eight developed satisfactorily, namely, *Medicago hispida*, *Melilotus indica*, *M. officinalis*, *M. alba*, *Lotus corniculatus*, *Trifolium carolinianum*, *T. repens* (Ladino variety), and *T. pratense*. All the species flowered and fruited within five months, *Medicago hispida* in four and a half. The average temperature was 19°C. and rainfall was relatively abundant and well distributed, but it is probable that these species would do well in warmer climates and with less rainfall.

In addition to this trial a sowing of *Vigna vexillata*, a species of cowpea, was made in 1943. Seed obtained from the United States was used, and during the twenty months for which it has been growing, including a specially trying dry season of over six months (1943-44), results have been excellent. The plant is especially promising for regions in which lucerne, red clover and other legumes cannot be grown. (Klugh and Rugeles, 1944. Rugeles, 1944.)

(vii) General observations

The foregoing examples suffice to show that in Latin America also erosion has already assumed alarming proportions, and it is a sobering thought to realize that the problem is due entirely to the activities of the early colonists and, still more, of their successors. As Bennett has pointed out, the Indian civilizations of Peru, Chile, Mexico and elsewhere thoroughly understood the cultivation of steep hillsides and the building of conservation and irrigation works long before the coming of white men, and they took almost unbelievable pains to protect their lands. "The way these prehistoric American farmers adapted their agriculture to the conditions of adverse climate and slope is one of the most remarkable achievements in the long history of man's struggle for existence." (Bennett, 1942.)

The most hopeful recent development is the policy of sending scientists from the Latin American countries to undergo a course of definite training in soil conservation under the United States Soil Conservation Service. Argentina, Brazil, Haiti, Mexico, Paraguay, Uruguay and Venezuela are already profiting by the experience and activities of the trained personnel ; and Colombia, Costa Rica, Ecuador, Guatemala and Peru are all participating in the scheme. (Hull, 1945.)

The problem is, however, an international one, and from Argentina a voice has been raised to urge the establishment of an International Anti-desert Institute, to be composed of representatives of every country faced with the problem of erosion, for the pooling of experience to enable the formation of immediately applicable means of defence. (Moreno, 1942.)

CHAPTER 10

ANIMAL AND PLANT HEALTH

(i) Veterinary problems

Of these, two in particular are of importance in their relation to the grasslands of Latin America, namely, osteomalacia and the tick scourge.

DEFICIENCY DISEASES. URUGUAY

Closely related to the increasing amount of soil exhaustion is the growing occurrence of osteomalacia and similar deficiency diseases in South American stock. Under the National Commission for the Forage Problem in Uruguay, careful study has been made in recent years of the grasslands affected by osteomalacia in that country. They form three main groups: (a) low-lying, relatively flat lands in the eastern Departments of Treinta y Tres and Cerro Largo, more or less adjacent to Lake Merim; (b) prevalently sandy grasslands in some zones of western, central and northern Uruguay; and (c) poor, stony grasslands. The plant cover of the osteomalacia zones is characterized by the entire or almost entire absence of legumes. In the first group, in addition to stoloniferous grasses, hard xerophilous types such as *Aristida* species, *Danthonia cirrata*, *Piptochaetium*, etc. are dominant, and some coarse grasses, the most frequent being *Andropogon lateralis* var. *incanus*. In the second group coarse grasses such as *Andropogon condensatus*, *A. ternatus*, *A. lateralis* var. *incanus*, etc. are dominant, in the better parts stoloniferous grasses are frequent and sometimes dominant. Legumes are present sporadically. Successful results have been obtained in Uruguay from distributing in the affected zones a mineral lick containing phosphates, calcium and sodium chloride; not only have the symptoms of osteomalacia been controlled and vigour been increased, but parturition also has increased by approximately 20 per cent or 325 thousand calves per year. (G. E. Spangenberg, 1940.)

Fynn has mapped the regions concerned, and soil analyses which he presents for the different types of affected land demonstrate the especially great impoverishment in calcium. As it is not possible, economically and in practice, to apply fertilizers to such extensive areas, the mineral lick described above has furnished a temporary solution. Other mineral deficiencies of Uruguayan land, such as that of iron in the sandy regions, are being studied with a view to the distribution of suitable correctives. (Fynn, 1940.)

The problem is an urgent one, because the calcium phosphate deficiency results in a great lowering of the fertility index. In definite osteomalacia regions this, for cattle, is in extreme cases 30 to 40 per cent, as against 80 to 90 per cent on good pasture land. The scale of susceptibility to osteomalacia is as follows: cattle (the most susceptible), sheep and goats, horses and pigs. Improved breeds of cattle are more liable to suffer, as are also cows with calves. (Boerger, 1938a and 1939b. Rubino, 1935.)

A description of representative localities in the eastern and western osteomalacia zones, with special reference to soil composition and the vegetation found in each, was published by Spangenberg in 1938. The eastern zone differs from the western not only in soil composition but in the climate, which is colder, resulting in plant growth being later than in the west. (G. E. Spangenberg, 1938.) Another account of an osteomalacia area in the north-western province of Artigas was given by Spangenberg and Riet in 1939.

From 1937 to 1939, 31,000 kg. of mineral lick were distributed to Uruguayan graziers by the National Commission, and the results were entirely satisfactory. Montedónico, Fynn and Vedani,

who report on this work, warn the public concerning the composition and unsatisfactory nature of several commercial preparations claiming to have the same effect, and they suggest legislation for the protection of the farmer. (Montedónico, Fynn and Vedani, 1939. Fynn, 1940.)

DEFICIENCY DISEASES. BRAZIL

By Chaltein and Rouget Pérez, two scientists working in the State of Rio Grande do Sul, Brazil, osteomalacia in cattle is considered to have a parasitic origin. Their finding is based on studies carried out from 1924 to 1927.

"Just as in other animal species there are found osseous lesions which are the result of worm infestation, such as rickets in dogs and swollen face in horses, we believe, on the basis of our observations, that *Oesophagostomum* sp. (*O. radiatum* ?) is capable of producing a state of malacia, because : (a) *Oesophagostomum* deeply wounds the intestine in the course of its development, leaving after the termination of its life cycle a purulent focus ; (b) the intestine, perforated in thousands of places, becomes irritated and its assimilative functions are disturbed, resulting in an increasing degree of thinness from the moment the disease begins ; (c) the very numerous purulent foci constitute magnificent points of entry for the germs existing in the intestinal flora : (d) like the other worms of the same family, *Oesophagostomum* secretes toxins which can influence the nervous system and the endocrine glands and in this way greatly disturb the nutritional equilibrium of the organism in general, even to the point, according to circumstances, of the rarefaction of the bones, of the ossein or of the calcareous salts (osteomalacia).

" . . . The disappearance of the parasite produces an immediate improvement in the general nutrition of the animals, and there is then seen a diminution of the loss of calcareous salts in the urine and a recalcification of the bones attacked."

Treatment with a vermifuge pure and simple has been found to give good results. (Chaltein and Rouget Pérez, 1927 and 1928 ; quoted in Boerger, 1943.)

DEFICIENCY DISEASES. ARGENTINA

In Argentina the osteomalacia problem has received attention chiefly from veterinarians. Rubino lectured on the subject to the Faculty of Agronomy and Veterinary Science of the University of Buenos Aires in 1934, describing the symptoms of the disease and its relation to phosphorus deficiency in pastures, and indicating measures for improving the latter. (Rubino, 1935.) Gómez and Quevedo presented a paper to the First Argentine Congress on Agronomy on the osteomalacia found to be prevalent in the south of the Province of Corrientes in cattle of all ages, in practically the whole of the territory having soil known to be poor in mineral components (calcium and phosphorus). The collaboration of agronomists for the solution of the entire problem was noted as indispensable. (Gómez and Quevedo, 1941.)

Rete has discussed the disease of hypocalcaemia in cattle and sheep from the veterinary standpoint. It is characteristic of lime-deficient grazings and is associated with certain climatic conditions. Care should be taken on warm, moist winter days to graze animals in the pastures concerned either not at all or for a few hours only, the ration being completed with hay or some sort of conserved feeding-stuff. (Rete, 1942.)

Preventive measures are suggested to farmers and graziers by Lerena, Director of the Clinical Institute, Buenos Aires, in a dissertation on the veterinary aspects of osteomalacia. "Burn the fields in which cases of osteomalacia occur, drain the pools and depressions. Manure the land with bone meal or lime. Apply sulphate when helminthiasis is found in the animals. Cultivate the land, and do not use it again for cattle until after a rest of two years. The best hay is that rich in legumes, which may be given together with a suitable quantity of grain and meals. The fields should be sown with legumes such as *Medicago sativa*, *Trifolium*, *Lupinus*." The importance of legumes in preventing osteomalacia is stressed, and it is said that the hay fed to dairy cows should consist for at least one-half of legumes. Attention is drawn to the loss of bone through

exporting cattle, and the salvage of bone from all possible sources in the country is urged in order that the deficiencies of the grazings may be somewhat corrected. Lime may also be used for this purpose. It is believed that the day will come when legislation will be necessary to prevent the export of bones. (Lerena, 1938.)

DEFICIENCY DISEASES. COLOMBIA

Ospina, of the National Department of Animal Husbandry, Colombia, has reported that the soils of that country have a minimal quantity only of mineral substances such as calcium, phosphorus, magnesium, iron, sulphur and iodine, and that the administration of salts to stock is a necessity. He gives doses and compounds suitable for different types of animal, and states that salt should be available at all times, preferably in the form of a block which can be licked at will. Attention is drawn to the need of grading the quantity of mineral rations in accordance with the stage of development of the herbage available. (Ospina, 1942.)

A new slaughterhouse is to be erected at Villavicencio, south of Bogotá, Colombia, with an initial capacity of 100 head of cattle per day, to be increased later to 200, having refrigeration plant and designed to permit the maximum use of waste products. The bones, hides, hoofs and horns will be used by Colombia's *Instituto de Fomento Industrial* for its new fertilizer factory and will help to restore the fertility of the badly depleted western llanos. (*Agriculture in the Americas*, 1945.)

THE TICK SCOURGE

Perhaps the greatest scourge of the pastoral industry of Latin America is the tick (*Boophilus microplus*). Its presence, like that of other insect pests and parasites of stock, appears to be governed principally by temperature and climate, hot, humid localities being especially liable to infestation. James, suggesting the use of the Basin of Mexico for stock raising rather than crop cultivation, notes that the temperatures there are low enough to reduce insect pests to a minimum (James, 1941, p. 655). Nyhus has mapped the approximate boundary between the tick-infested and tick-free areas in Argentina, the line running roughly east and west from the neighbourhood of the towns of Paysandu in Uruguay, Concepción, Santa Fé and Córdoba. (See Fig. 8.) "Broadly, it may be stated that northern Argentina is tick-infested while the southern areas, including the larger part of the La Plata Basin, are tick-free." Progressive ranchers in Argentina and Uruguay (where, however, the tick problem does not appear to be so serious) round up their cattle for systematic dipping, approximately fortnightly. (Davies, 1940.)

THE TICK. MEASURES FOR CONTROL

Lerena in 1938 warned graziers of the necessity for intensifying efforts to control the infestation of animals by parasites, and now Government action has been taken in Argentina. Law No. 12,566 imposes an obligatory control of ticks, a Division for Tick Extermination has been established under the Ministry of Agriculture, and work is in progress, at all events in the Province of Entre Ríos, the whole central part of which—it is hoped—may be declared a "clean zone" within a relatively short time. (Tagle, 1943.) The Division has its main office in Buenos Aires and nine inspectorates in different parts of the country, and supervises the working of sixty official and controlled dipping establishments situated at strategic points of the infested zones. The movements of stock in or out of infested zones is controlled and the ranches are classified in accordance with their degree of freedom from ticks. In propaganda to farmers the Division urges fortnightly dipping, because the tick reaches maturity and oviposition within seventeen days. Arsenical dips are available at low prices. The dose should be regulated in accordance with temperature. Costs of dipping are outweighed by the incomparably superior product and the

economic advantages obtained. Breaking up the ground and burning the coarse grasses are commended as auxiliary measures of great importance for tick extermination. (*Almanaque Min. Agric. Argentina*, 1938, 1941, 1942, 1943.)

In Brazil also, ninety-one official dipping stations are operating under regional inspectorates. (Brazil, Min. Agric., 1940.)

TICKS AND *MELINIS MINUTIFLORA*

There is a common belief that *Melinis minutiflora*, a Brazilian grass that is becoming increasingly widely distributed throughout Central and South America, is repellent to ticks as well as mosquitoes and snakes. This has been attributed to a pungent odour due to the secretion of an oily substance (*J. Jamaica agric. Soc.*, 1941), a theory not accepted, however, by Agnes Chase, who points out that *M. minutiflora* does not grow in wet grounds where mosquitoes breed, and that the "seed ticks" which normally climb vegetation and attach themselves to passing animals are caught in the gummy, velvety foliage of this grass and are unable to transfer to grazing livestock. (Chase, 1944.) For either reason, however, in tick-infested regions *M. minutiflora* is obviously advantageous as tending somewhat to reduce attack.

SPRAYING VERSUS DIPPING

A new approach to the problem is reported from Costa Rica. The efficiency of dipping tends to be limited by the enormous areas occupied by South American grazings. Squibb reports that the province of Guanacaste in Costa Rica, where most of that country's meat cattle are congregated, has only one tick bath for every 14,000 head of cattle, and the animals are scattered over the province in such a way that in some cases they have to be driven for twenty-four hours under tropical conditions before they can reach it, so that loss of weight and of milk yield and even injury ensue. The baths are not popular with ranchers, moreover, who find them costly, not so much in construction as in the working. Squibb proposes a new method of control through the use of a solution of rotenone and DDT, applied by means of an ordinary atomizer. Experiments at the Inter-American Institute of Agricultural Science in Costa Rica with over 8,000 animals have proved the results obtainable to be superior to those achieved through dipping; the disadvantages noted above are avoided, and rainfall after spraying does not prevent the obtaining of 93 per cent mortality. In already infected grazings the sprayed animals themselves constitute a means of control. It is claimed that very far-reaching results could be achieved by the use of this method on a large scale. (Squibb, 1945.)

(ii) Plant pests

From the grazier's viewpoint it is probably the locust which inflicts the most damage.

LOCUSTS

DIFFERENT FORMS OF DAMAGE

Information comes mainly from Argentina. In some parts of this country serious loss is due to locust depredations. Writing of the La Plata Basin, Province of Entre Ríos, Davies says: "One of the difficulties in this countryside is the recurrent plagues of locusts. These are surface feeders, which defoliate everything in their path, leaving no trace of green vegetation. Attempts are always being made to deal with the locust on a national scale, but there appear to be a number of serious difficulties consequent upon sporadic migration of the pest, which moves over large areas in a short period of time. The locust is likely to be a deterrent factor in the intensification of pastoral agriculture in these districts." (Davies, 1940.) Burkart (see p. 139) notes the damage done by species of the genus *Trigonophimus* and others to lucerne and lucerne seed cultures in Argentina. (Burkart, 1945b.)

In Uruguay also locusts are the cause of serious damage. Spangenberg and Henry wrote in 1938 that for the last eight years intense and consecutive invasions of locusts had plagued the country, the most affected area being the western Departments of Artigas, Salto, Paysandú, Rio Negro and Soriano. The southern and central Departments are also attacked, although somewhat less seriously, but the eastern part of the country has remained as yet relatively free of the pest. (See Fig. 9.) (G. E. Spangenberg and Henry, 1938.)

The damage is not confined to the destruction of green vegetation. Fernández, Bonjour and others have found that increased toxicity is produced in Sudan grass through attack by locusts. (See pp. 179-80, Fernández, 1933. Bonjour, 1934, 1937.) This is true of sorghums generally, and while the attack of other insects also may have the same effect (Argentina, Dir. Ganad., 1941), mass attack by locusts is most to be feared.

OVERGRAZING AND THE LOCUST

Nor is the destruction of herbage and forage crops and other damage the only relation of the locust to grassland, for frequently it is the mismanagement of grassland which creates conditions favourable for the propagation of the locust. Uvarov considers the excessive grazing of natural grasslands to be one of the principal causes of the growing menace of locust attack in Argentina and elsewhere in South America. (Incidentally this author mentions that the felling of forest in the west of Australia, with the object of providing sheep grazings, has created a type of grassland admirably suited to the propagation of the locust.) (Uvarov, 1944.) Liebermann also notes that measures such as overgrazing regions of low rainfall, destroying the indigenous flora and with it plants that harbour the insects parasitic on locusts, devastating woodlands and draining ponds and lakes with a consequent reduction of bird life, are all productive of the mass development of locusts. (Liebermann, 1944a.)

DIVERSITY OF SPECIES

The number of different species of locust concerned adds greatly to the complexity of the problem. Liebermann reports that, in addition to the common migrant *Schistocerca paranensis*, hundreds of other species are found in Argentina. These others are less widely distributed, but constitute local plagues of importance. Among species recorded as injurious are the following: *Dichroplus elongatus*, on lucerne cultures as well as orchards; *Trigonophymus vittatus*, on maize and lucerne cultures; *T. pratensis*, on maize cultures and grasslands; *Scyllina variabilis* on grasslands; *Scotussa rubripes* on natural grasslands; *Dichroplus bergi*, on lucerne cultures. (Liebermann, 1941, 1942.) The same author, who traversed the whole of Chile in 1942 and 1943, observed that the genus *Dichroplus* is a cause in that country of serious loss, especially of the forage and herbage which tends to be short in any case. The crops concerned include lucerne, clover (*Trifolium* spp.) especially in Colchagua, the seed production centre; grass cultures; and maize. (Liebermann, 1944b.)

PLANTS REPELLENT TO THE LOCUST

A partial solution for the farmer in menaced regions is the growing of plants known to be repellent to the locust. Spangenberg and Riet mention that *Grohoma sorghum* is unpalatable to locusts (G. E. Spangenberg and Riet, 1939); and there is a South American variety of maize, known as "bitter" maize, which is immune to attack by *Schistocerca paranensis* even when surrounding cultures of ordinary maize are seriously damaged. It is resistant also to the grasshoppers *Dichroplus arrogans* and *Scyllina variabilis*. The popular name of this variety indicates the supposition that it is a bitter principle which repels the locust. To test this, Bredemann and Radeloff at Hamburg made (a) feeding trials with *Carausis morosus* (in the absence of *Schistocerca*); (b)

chemical tests ; and (c) a morphological study of the leaves of six maize varieties, including bitter maize. It was considered probable that the very numerous, unusually large, stiff, erect and siliceous hairs which distinguish the leaf surface of the bitter maize from that of ordinary varieties are responsible for its rejection by locusts, since the chemical tests for bitter principle, alkaloids and HCN gave negative results ; tannic acid content was somewhat lower in the bitter maize than in the control varieties ; and the expressed sap of the bitter variety was taken readily by the experiment insects when administered on the leaves of ordinary varieties, but rejected when administered on the leaves of the bitter variety. (Bredemann and Radeloff, 1938.) As early as 1913 Schroeder also was unable to isolate any toxic or bitter principle, and considered the resistance due probably to the cellular structure of the plant or to physical reasons. (Schroeder, 1913, quoted by Boerger, Canel and Burdinski, 1939.) Horovitz and Marchioni, on the other hand, who studied the inheritance of resistance to locusts in this variety, do not believe the character to be related to the hairs of the leaf surface, nor did they find any visible character correlated to the susceptibility or resistance of the plants, such as the presence or absence of anthocyanic flavones and other pigments. While the reason for the resistance of bitter maize still remains obscure, although it is probably related to that of *Tripsacum* to insects (Horovitz and Marchioni, 1941), certain disadvantages attach to the growing of this variety in some latitudes. In Uruguay, for example, its growth period is too long, its maturity too late, and its habit of becoming excessively tufted is found inconvenient for cultivation. The use of such plants is, indeed, only a temporary solution of the locust problem. (Boerger, Canel and Burdinski, 1939.)

RESEARCH AND MEASURES FOR CONTROL

The gravity of recurrent plagues of locusts is recognised by the Argentine Government, which has an Institute for Research on the Locust working under the Plant Health Directorate of the Ministry of Agriculture. (*Almanaque Min. Agric. Argent.*, 1941.)

Goytía has enumerated the methods of locust control used by the Argentine Directorate for Agricultural Defence. (Goytía, 1940.) Advisory articles on locust control are published in the Argentine Ministry's yearbook and in the popular press, and Government equipment is freely used in regions liable to attack. Modern methods of control include the application of dinitro-ortho-cresol dusts by means of apparatus mounted on motor lorries. By this means 200 million kg. locusts were destroyed in 1938 and 470 million kg. in 1939. Aeroplanes are sometimes used for the application of dusts of this kind. (Tomasello, 1941.) Motor-driven sprayers have been very successful in the provinces of San Luis and Córdoba, and the work is to be extended to the province of Tucumán. The locusts generally congregate in a compact mass covering several hectares, and several thousand kg. can be destroyed in a few days. (*Noticioso, B. Aires*, 1944.) Schiuma has published a control calendar, showing measures that may be employed month by month against *Trigonophymus arrogans*. Importance is attached to the destruction of the eggs in lucerne and similar crops by means of disk harrows and other implements. Sudan grass should be sown early in October, because late sowings are more liable to attack. Ditches for the collection of the insects, barriers and the use of flame-throwers are also recommended. (Schiuma, 1938.) Sosa likewise recommends the flame-thrower, which is obtainable at cost price through the Argentine Ministry of Agriculture. It should be used in the early hours of the day. (Sosa, 1939.) The successful use of flame-throwers is reported also from Ecuador, where in the province of Imbabura it is found that a percentage of 50 to 60 can be destroyed by using the implement between 3 and 8 a.m., when the dew prevents the massed locusts from flying. (Rodriguez, 1942.)

Marchionatto, Director of the Plant Health Division of the Argentine Ministry of Agriculture, has suggested the possibility of biological control by means of two fungi common in Argentina,

Beauveria globulifera and *Sporotrichum paranense*, both of which are parasitic upon *Schistocerca paranensis*. (Marchionatto, 1934.)

LOCUSTS AN INTERNATIONAL PROBLEM

Uvarov writes in 1944, however, that in spite of the great efforts made to deal with the evil in Argentina and elsewhere results have always been ephemeral and a radical solution of the problem of the locust has never been found, for the simple reason that it is insoluble within the limits of a single country. Clouds of locusts cover great distances without taking any account of frontiers. It is clear that the means of defence adopted in one country, however effective they may be, can only protect the existing cultures at the time of the invasion, but leave the general problem untouched. Under the International Locust Control Committee, the work from 1930 to 1938 of a large number of scientists from all parts of the world has brought to light much valuable information on the causes of periodic locust invasion, and a Committee was formed in 1942 to search for radical means of prevention. Of this Committee, Uvarov, a representative of Latin America, is in charge of technical direction. (Uvarov, 1944.)

OTHER PESTS

FORMICIDAE

In some parts, for example, the Brazilian State of São Paulo, locust invasions are of short duration and rarely affect grasslands, but ants are a very real menace to the productivity of pastures. The most destructive species are those known as *sauva* ants. Where they are allowed to work unmolested whole pastures can be undermined by their activities, which consist in the underground storage of plant material for the formation of the fungus on which they feed. (Pheysey, 1947.) The Brazilian Ministry of Agriculture speaks of this pest as "the commonest in the country and that which causes the most damage". The use of arsenic and carbon bisulphide are recommended as efficient and economical means of control, suitable appliances being obtainable at cost price from the Ministry. (Brazil, Min. Agric. 1940.)

TOXOPTERA GRAMINUM

Of importance in connexion with the rapidly growing practice of grazing cereals is the appearance of a new cereal pest, namely, *Toxoptera graminum*. The aphid in question, first described by Rondani in Italy in 1852 and first recorded for Argentina in 1914, has become a source of great damage. Boerger writes that in 1937 a catastrophic invasion of this insect took place in Uruguay and large areas of Argentina, and that it has been a serious and constant source of trouble ever since that date. At La Estanzuela it has been found that early wheat sowings and oats grown for grazing are most exposed to destruction. Hayward says that young or poorly-developed sowings are those most liable to attack. This author discusses the damage caused, natural enemies and measures of prevention and control. The latter include the cleaning of the land—especially of grasses—before sowing, and sowing early. Crops or portions of crops seriously infested must be sacrificed to prevent a wider distribution of the pest; they may be destroyed by means of a flame-thrower, or may be ploughed in or grazed. (Hayward, 1940. Boerger, 1943, Vol. 1.)

Griot, studying the possibility of controlling the pest by means of its parasite, *Aphidius platensis*, in experiments at the Provincial Experiment Institute of Animal Husbandry, Santa Fé, Argentina, records that while the parasite is a valuable aid, it is inadvisable to rely entirely upon this means because, among other reasons, it requires 15 to 20 days to complete its life cycle while the pest requires 10 days only. The critical stage of the plant for attack is from germination to shooting, and if development is rapid and the plant is leafy in consequence of adequate moisture

its resistance is greater. The factors governing control are in the first place soil moisture, and only afterwards—as an ally of the first factor—the presence of *Aphidius platensis*. Artificial dissemination of the latter is unnecessary in Santa Fé, where the parasite exists naturally; the best measure of defence is deep ploughing with a view to the accumulation of much water. (Griot, 1944.)

DIATRAEA AND COLIAS

Another pest relatively new to Uruguay that may be mentioned is *Diatraea saccharalis*, a sugar cane pest which also attacks sorghum, maize, and herbage grasses. A natural enemy has been found in a species of *Ipobracon*. (Ruffinelli, 1943.) *Colias lesbia*, a species of the Lepidoptera, is a serious pest of lucerne seed cultures in Argentina. (Burkart, 1945*b*.)

ANGUILLULINA SPP.

A nematode, *Anguillulina dipsaci*, is an increasing cause of heavy loss to Argentine lucerne cultures, but breeding for resistance offers a measure of control. (See p. 140. Burkart, 1937*e*, 1943*b*. Ragonese and Marcó, 1943.) Another nematode, *A. radicola*, was observed on *Poa annua* in Buenos Aires in 1935. It is a northern European species and appeared to have been introduced into Argentina, its incidence being fairly well localized. (Burkart, 1935*b*.)

ACANTHOSCELIDES OBTECTUS

Duran and Fauré have studied the plant hosts of the common bean weevil (*Acanthoscelides obtectus*) in Chile. In material collected the weevil was found living on seeds of sixteen varieties of *Phaseolus vulgaris*, two varieties of *P. multiflorus*, on *Dolichos lablab* var. *albiflorus*, *Vigna sinensis*, *Vicia faba* f. *megalosperma* and *Cicer arietinum*. *Dolichos lablab* is believed to be a new host plant. Seeds of twenty-five plant species suspected of harbouring *A. obtectus* were collected and "sown" with weevil eggs under optimal conditions for development. Penetration was more or less deep, development of the insects being successful in *Lathyrus odoratus* (apparently a new host), *Lens esculenta* and *Pisum sativum*. (Duran and Fauré, 1944.)

(iii) Fungous parasites

CLAVICEPS

Of the fungous parasites of plants, the most troublesome to the grazier are those which render grasses poisonous to stock, namely, *Claviceps paspali*, *C. purpurea* and others. (See pp. 180-1.) Ringuelet recorded in 1936 that a large proportion of the *Spartina* which grows in abundance in the Bay of Samborombon, Argentina, was attacked by *Claviceps purpurea* in the autumn (end of March to the beginning of April). He described the manner in which *Spartina brasiliensis* and *S. montevidensis* respectively are affected. There is little risk of cattle poisoning in this particular region, because grazing is usually carried out at higher altitudes than those occupied by the grass. (Ringuelet, 1936.)

Montoro Guarch (1932) has reported the presence of ergot on *Spartina* spp. in Uruguay also. Hauman and Parodi (1921), while noting that this parasite is very common on *Spartina montevidensis* in Argentina, further recorded its presence, although very rarely, on rye and barley. More recently Fischer (1935) found a forage barley strain in Uruguay infected with *Claviceps purpurea*. The strain had been received originally from Chile (1921) but had been reproduced in Uruguay. The attack was slight and is considered an accidental case with little risk attached. (Fischer, 1935.) Herter (1937*b*) observed *Claviceps purpurea* on adventive *Lolium*.

Carrera, in a study of *Fusarium* species, has noted that *Fusarium heterosporum* v. *lolii* may commonly be observed on the spikes of *Spartina* when the latter are attacked by *Claviceps*, but that

it has not been observed on healthy spikes. *F. heterosporum* is also recorded for *Lolium* attacked by *Claviceps*. Bitancourt records *Claviceps paspali* for *Paspalum plicatulum* and *P. proliferum* in the state of São Paulo, Brazil. Marchionatto has presented a biological description of this fungus. (Carrera, 1936. Bitancourt, 1940. Marchionatto, 1937.)

ENDOPHYTE OF *LOLIUM TEMULENTUM*

Marchionatto, in a preliminary study of the endophytic fungus of *Lolium temulentum*, has found the fungus to be present in approximately 75 per cent of Argentine seed of *L. temulentum* and in 25 per cent of *L. multiflorum*, but it was absent in *L. perenne*. (Marchionatto, 1939.)

USTILAGO

Bromus catharticus is an important forage grass, but at La Estanzuela, Uruguay, it has been found extremely susceptible to attack by *Ustilago bromivora*. Ratera reports that when this fungus is present *Bromus catharticus* is poisonous. Bentancur found hot-water treatment of the seed (immersion for 110 minutes at 47° to 48°C.) to furnish the best means of control. (Bentancur, 1939. Ratera, 1943.)

HELMINTHOSPORIUM

Helminthosporium turcicum is a common fungus in Argentina, and recently two hosts new for that country are recorded, namely, Sudan grass or *Sorghum sudanense*, and *Sorghum caffrorum*. The finding is important in view of the extensive cultivation of Sudan grass in the Argentine Republic. (Campi, 1939.)

Montoro Guarch has reported that *Helminthosporium ravenelii* Curtis is widely distributed in Uruguay, especially in moist localities, where it is found on the inflorescences of *Sporobolus poiretii*. The grass itself is hard and of little value for grazing, but the parasite is so common that it comprises a noteworthy component of the vegetation. According to Ratera, the presence of this fungus renders the grass in question poisonous. (Montoro Guarch, 1941. Ratera, 1943.)

SCOLECOTRICHUM GRAMINIS

Montoro Guarch also records that *Scolecotrichum graminis* [= *Passalora graminis*] has been observed, for approximately two years and in almost every part of Uruguay, to cause a certain amount of damage to *Bromus catharticus*, to the introduced *Dactylis glomerata*, and, in its variety *brachypoda*, to *Secale cereale*, a crop not as yet of much importance in Uruguay. Symptoms are described. In the case of the first-named grass, attacked plants in some places attain a height of 10 cm. only, instead of the normal 30 to 60 cm. (Montoro Guarch, 1941.)

(iv) Weeds

Space forbids any full discussion of the weed question as it affects Latin American grasslands. Parodi has given a detailed account of weeds of wheat, maize and other crops in the Argentina pampa, and Marchionatto has published a list of the Argentine weeds generally and of the fungi attacking them. A most helpful and informative account of the weed problem of Uruguay and of the La Plata zone is to be found in Vol. 1 of Boerger's recently published work on agricultural research in that region. Rivera and Breton have written on weeds of Mexico and Katz on those of Ecuador. (Parodi, 1926c, 1943e. Marchionatto, 1940. Boerger, 1943, Vol. 1, Chap. 7. Rivera and Breton, 1940. Katz, 1943.)

The amazing manner in which species introduced from the Old World thrive and spread under New World conditions has already been noted in the case of *Cynara cardunculus* and *Silybum marianum* in the Argentine pampa (see pp. 18-9). This capacity has created a very serious problem

in the case of one or two introduced forage plants which have escaped from cultivation. An example is found in Johnson grass.

JOHNSON GRASS

Sorghum halepense was introduced into Argentina some forty years ago as a forage plant, but by 1930 had become such a menace to agriculture that a decree was passed (3rd December, 1930) to prevent its sale and enforce its eradication. The poisonous nature of this plant when young adds to its nuisance value.

A study of the plant by Cross has revealed its weak point in the root system, which, together with the rhizomes, depends upon the aerial parts of the plant for sustenance and development. Control should attack this weak point by continuous cutting or grazing. The exhausted roots and rhizomes can subsequently be ploughed up. Sodium chlorate, as a dust or in solution, is useful where plants are inaccessible for other means of control (by roadsides, ditches, etc.). Means for avoiding the introduction of the weed from other places are enumerated. (Cross, 1934*b*. Parodi, 1926*c*.)

In Uruguay also, Johnson grass has been declared a public enemy by a decree dated 6th December, 1939. (Boerger, 1943, Vol. 1.)

From Peru comes a similar story. *Sorghum halepense* was introduced into that country forty years ago as a good summer grass, since when it has spread enormously and in some parts constitutes such a menace to crop cultivation that whole areas formerly occupied by cotton, etc. have been abandoned to it. The chemical control found effective elsewhere is impracticable for the wide areas infested in Peru. Several years' experimentation with various implements has shown that the only effective means of control is the repeated cutting away of the parts of the plant that are above ground so as to prevent seeding, and an instance of the successful cleaning of a badly infested cotton plantation is described in detail. While most planters are now making efforts to control this weed in plantations and arable land, the sources of infestation—canal and river banks, waste land, etc.—still remain untouched, and the necessity for regulations enforcing landowners to deal with the menace is noted. (Belaunde, 1941.)

NUT GRASS

Another formidable invader is nut grass, *Cyperus rotundus*, which is reported to have become an increasingly serious intruder in the agricultural lands of northern Argentina during the last twenty years. The only invasion comparable with it is that of Bermuda grass (*Cynodon dactylon*), which affects the same region. *Cyperus rotundus* attacks the most fertile lands, withdrawing nourishment from the crop plants. The plant is propagated by seed and by the vigorous growth of the multiple rhizomes forming around the mature root tubers, and a dangerous method of aggression has been discovered in potato fields, where a relatively large number of potatoes have been found to contain the characteristic tubers of nut grass. The sharp rhizome of the nut grass pierces the potato, the nut grass tubers are formed in the potato tuber and continue to develop there; the parts of the rhizome dry and disintegrate and the potato closes up over the point of entrance, so that the potatoes containing the active nut grass tubers have a normal, well-developed aspect and there is nothing to prevent their being used for seed and constituting fresh points of dissemination.

Farmers and especially citrus planters are recommended to check the growth of nut grass by sowing in October or November the velvet bean or the Lyon bean (species not stated), and passing a disc harrow over the growth in the following April or beginning of May, leaving the whole on the ground until the winter. The nut grass which in spite of this treatment reappears in the

following spring should be cut by a cultivator having vertical tines, and this cutting should be repeated as often as the nut grass reaches a height of 6 to 8 cm. Of the many methods of control tested, the above is the only one that has proved effective. (Schultz, 1942.)

Nut grass, it is true, like *Cynodon dactylon* and *Sorghum halepense*, has spread from the grazing to the culture, but all these species in grazings also tend to oust more valuable herbage plants. Most of the serious weeds of the South American grasslands, however, have spread from the culture to the grazing, and are frequently of European origin. In Argentina and Uruguay, examples are *Xanthium cavanillesii*, described by Ratera as poisonous and decreed by Argentina in 1914 and by Uruguay in 1915 to be noxious, the eradication of which is obligatory; *X. strumarium* and *X. spinosum*, both decreed to be noxious by Uruguay (1915 and 1924); *Wedelia glauca*, declared by Ratera to be poisonous and decreed noxious by Argentina in 1932; *Cirsium lanceolatum*, *Centaurea calcitrapa* and *C. melitensis*, all three decreed to be noxious by Uruguay in 1924, and others. (Boerger, 1943, Vol. 1. Ratera, 1943.)

WEEDS OF LUCERNE CULTURES

The Argentine lucerne cultures have their own special accompanying weeds. Lanusse lists the following species as the principal adulterants of Argentine lucerne seed: *Cuscuta indecora*, *Melilotus indica*, *Salsola kali*, *Plantago lanceolata*, *Centaurea solstitialis*, *Setaria geniculata*, *Polygonum aviculare*, *Rumex crispus*, *Anthemis cotula*, *Chenopodium hircinum*, and *Amaranthus quitensis*. Parodi mentions also *Brassica* species, *Raphanus raphanistrum* and *Thlaspi arvense*. A relatively recent and dangerous invader is *Centaurea repens*, recorded in 1944 by Ibarra and La Porte for the lucerne cultures of the Patagonian valleys.

Guyot has published an article on weed growth in the lucerne fields of the upper valley of Rio Negro, Argentina, in which cultivation with disc harrows in the spring is recommended. Attention should be paid to the water relations of the soil, since stagnant moisture equally as lack of irrigation water produces weed growth. The first cut, always most liable to be invaded by weeds, should be taken before the weeds seed and should be fed to stock, but never used for the production of lucerne seed. The practice of grazing lucerne areas for several successive years leads to the spreading of weeds: in such cases it is recommended to divide the fields into well-fenced paddocks to be alternately grazed and cut, cultivation in the spring not to be neglected. In irrigated lucerne, the necessity of cleaning the water channels of weeds is stressed. Patches of weed growth should be cut and if possible burnt.

(Lanusse, 1937. Parodi, 1941c. Guyot, 1942. Ibarra and La Porte, 1944.)

CUSCUTA

Cuscuta in Latin America is considered chiefly in connexion with lucerne cultures. The most widely distributed species in Argentina, both in the irrigated lands and in the pampa, is *Cuscuta indecora* var. *longisejala*.

According to Parodi, the damage caused by it is, however, insignificant, and it disappears naturally from an area when lucerne has been grown there for two or three years. It is considered probable that this is attributable to its growth habit, which differs from that of the more injurious *C. epithymum* in that it does not grow up from the bottom of the host plant, but starts its attack at a certain height above the ground, being propagated chiefly at the upper extremity of the host. It forms spheroidal glomerules of 2 to 3 cm. in diameter. The *Cuscuta* is mown and removed together with the lucerne, and it is quite exceptional for fragments to remain in the field. Unless such fragments fall upon lucerne in full vigour of growth under high moisture conditions there is little prospect of their propagation; if they fall at the foot of the mown plants, they wither under the dryness and heat. (Parodi, 1936c.)

Martin notes that this species of *Cuscuta* is not restricted to lucerne, but has been found parasitizing, to a more or less serious degree, sixteen other plants, including the grasses *Digitaria sanguinalis*, *Echinochloa colona*, and *Cynodon dactylon*. (Martin, 1938.)

Cuscuta indecora was declared a "plague" in Argentina by a Government decree dated 17th September, 1912, its eradication being thenceforward obligatory. (Boerger, 1943, Vol. 1.)

In the early part of 1944 Hunziker, of the Faculty of Agronomy, Buenos Aires, surveyed lucerne cultures of the west and south of the Province of Buenos Aires and of the Territories of La Pampa and Chubut for the presence of *Cuscuta* and weed growth. For cleanness and closeness, cultures of the Argentine Valley in the Central Pampa were especially distinguished; *Cuscuta* is rare in this zone but *Salsola kali* is a troublesome weed. Agriculture in the valley of the Chubut River is described as poor and backward, and the lucerne fields are constantly menaced by *Lepidium draba*, much feared on account of its powerful root system, *Taraxacum officinale* and *Cuscuta campestris*. The last-named appears to be the only *Cuscuta* species of the regional lucerne crops, but this is said to be its first record for cultivated plants in Argentina. (*Rev. Fac. Agron., B. Aires*, 1944.)

Brazilian legislation concerning the importation of plants requires that all without exception must be accompanied by a certificate of origin and sanitary fitness, passed by the responsible office of the country of origin and endorsed by the Brazilian consul. Official examination is afforded gratis. For *Medicago* and other forage legumes a special certificate of freedom from *Cuscuta* is required in addition. The importation of lucerne from Argentina with a *Cuscuta* content of over ten seeds per kg. is prohibited. (*Bol. Agric. Minas Gerais*, 1933. Bruck, 1936.)

WEED CONTROL

In an experiment on the control of weeds in wheat fields conducted at La Estanzuela, Uruguay, Noll noted the value of adequate rotation and the use of temporary grazing leys for the purpose. (Noll, 1940-41.) The dangers of clean tillage and weeding, especially under tropical and sub-tropical conditions, have been stressed by Gruener (1941) in connexion with erosion in the Territory of Misiones, Argentina. (See p. 187.) Villegas notes the occasional usefulness of weeds for the conservation of moisture in loose, sandy soils and for impeding erosion on slopes. (Villegas, 1945.)

NUTRITIVE VALUE OF SOME WEEDS

Hudson has shown that the giant thistle of the pampa has its nutritive value. (See p. 19.) In Uruguay, where *Cynara cardunculus* and *Silybum marianum*, as in the Argentine pampa, cover enormous areas, a virtue has been made of necessity, large quantities of these plants being cut for silage. From 1936 to 1941, out of a total of 8,488 tons of silage made in Uruguay, 2,629 tons consisted of the above-named weeds. The silage produced is highly nutritive, and the practice tends to clear areas of the plants in question and to make room for more desirable species. In Argentina, also, lucerne containing *Carduus pycnocephalus*, *C. nutans* and *Silybum marianum* is ensiled, facilitating the control of the weeds concerned. (Boerger, 1943, Vol. 2. Nores, 1938. Burkart, 1945b.)

Pittier mentions an aromatic plant, *Hyptis suaveolens*, which is a weed found in great abundance throughout the Venezuelan Llanos. It is said that where this plant grows there are no ticks or snakes, but neither are there any cattle in its vicinity, for animals will not touch it. Its usefulness is therefore questionable unless there can be found some means of extracting oil from the seed or of using it as an insecticide. (Pittier, 1942.)

CHAPTER 11

MANAGEMENT AND IMPROVEMENT

By management is understood here the management primarily of the natural grasslands, but also that of sown leys, of forage crops and of farming generally.

The various problems which have arisen, and to which attention has been drawn in the foregoing pages, have led to a realization that improved management is not only desirable but urgently necessary. Much thought has been devoted to the subject by scientists and by progressive ranchers, but unanimity of opinion on the means to be adopted has not always been reached.

Burning

AIMS

A particularly vexed question is that of burning. Broadly speaking, burning may have one or more of three aims: the destruction of old herbage to make room for fresh, young growth; the destruction of woodland and undergrowth to provide grazing or arable land; and the destruction of pests and parasites. The burning of coarse grass, for example, is recommended as a useful auxiliary measure in the control of ticks. (*Almanaque Min. Agric. Argent.*, 1943, p. 203.) In the tropics recovery after burning is extraordinarily rapid, a fortnight suffices to make the landscape "greener than before" (Myers, 1933, p. 344), so that to the grazier in such lands burning for fresh herbage must be especially tempting.

To burn or not to burn? Opinions vary from a definite "Yes" to an emphatic "No", with a whole range of intermediate views which see burning as a necessary evil, but one to be avoided if at all possible and in any case to be carefully controlled.

IN SUPPORT OF BURNING

On the basis of thirty years' experience in various Brazilian States, C. Vincent considers unproved the charges commonly brought against the practice of burning (impoverishment of the soil in regard to humus and nitrogen, reduction of soil fertility, calcination of seeds, etc.). In his opinion burning, used with discretion, is one of the few economical measures available for improving botanical composition and the quality of herbage, and provides further the best means of controlling certain weeds and pests, epidemics and parasite diseases of stock. Agrostological and climatic conditions in the extreme southern States render it not so much a convenience as a necessity, and, in States in which conditions are analogous to those in the State of Rio de Janeiro, burning should be systematically employed for the conservation of the natural grasslands characterized by *Hyparrhenia rufa* and "murumbú", a variety of *Panicum maximum*. In certain definite cases, also, burning may be advantageous for those grasslands in which *Melinis minutiflora* is dominant. (C. Vincent, 1935.)

INTERMEDIATE OPINIONS

The intermediate opinion is typically voiced by Rueda and Reyes, who, writing of the natural savannahs of the hot Colombian lowlands, say that the native grasses composing these soon become fibrous, "which unfortunately makes their periodic burning necessary so that they may be used when sprouting afresh. With the burning, the plant cover diminishes and soil fertility is lost, but only artificial or improved pastures, fencing, and the provision of drinking facilities can deliver us from so great an evil." (Rueda and Reyes, 1941.)

Spangenberg regards burning as a necessary means of improvement in certain cases, and Spangenberg and Riet write of some coarse grasslands of Uruguay that they are burnt every year

so that the fresh growth may be grazed by stock. They note as advantages of this practice a partial diminution of the area occupied by the coarse grasses and the supplying of ash, which is eaten with avidity, to cattle in a mineral-deficient region. They add, however, that burning in stony lands counteracts productivity. (G. E. Spangenberg, 1930. G. E. Spangenberg and Riet, 1939.)

Watkins, referring to the pastures of El Salvador, says: "Burning is practised; although it has certain advantages, it destroys much of the organic material and injures the herbage." (Watkins, 1946.)

Parodi writes that in the Argentine province of Corrientes, especially the north, and in various parts of the Chaco and Formosa it is common to burn in summer in order to destroy ticks and encourage new growth. This practice, called locally "fire cleaning," has its advantages and its disadvantages. (Parodi, 1945c.)

Gonzalez, Cuba, writes that although frequent burning is destructive of soil fertility, under present conditions in Cuba it is not so injurious as it might appear, provided it is done at the beginning of the rainy season, in land well provided with organic matter and with a close plant cover, and not too often (every two or three years). There are certain advantages such as the cleaning of the land of ticks (although supplementary only to the necessary fortnightly dipping of stock) and the promotion of fresh sprouting. Moderation must, however, be observed if an excessive loss of fertility such as is recorded in parts of the province of Pinar del Río is to be avoided. (Gonzalez, 1945.)

Davies has noted the value of periodic burning to keep under control the shrubby growth which constitutes sometimes as much as 88 per cent of the Patagonian steppe vegetation. Flame-throwers are used for the purpose. It is stressed that the treatment must be skilful. "What is apparently required is a form of singeing, the burning of all dead leafage without creating enough heat to injure either the rootstock or any seeds lying on the surface of the ground. Ideally, too, the burn should be selective, for many of the edible shrubs, valuable assets in these grazings, do not recover after burning." (Davies, 1940, pp. 28 and 35.)

OPPONENTS OF BURNING

Of the opponents of burning, Pittier has already been quoted in connexion with the Venezuelan llanos or flood plains. (See pp. 123-4.) He maintains that the llanos are rapidly deteriorating, principally on account of the periodic fires to which they have been subjected. Useless plants are encouraged, nutritive plants are suppressed, ticks are not eradicated (since they are carried by the grazing animal itself), and soil sterility is produced. (Pittier, 1926.) Herein he is supported by Agnes Chase, of the United States, who writes that burning the llanos has diminished the better grasses until much of the eastern llanos, at least, are occupied by inferior species more resistant to fire. Nevertheless she opines that—"if burning is prevented"—the more valuable grasses may be expected to spread again. (Chase, 1944.)

As early as 1874 Hieronymus, writing of the Argentine province of Tucumán, described the custom as "pernicious". "Let us enquire why the pampas of the Argentine Republic are burnt. The rancher replies that by this means the animals obtain early, at the end of the winter, fine, tender herbage; but the same rancher is also apt to relate that fresh herbage of this kind is often injurious to animals which have been feeding for nearly the whole of the winter on the strawlike grass dried in the tuft, and that many of his herd have already died from the sudden change of diet. And in spite of this the pampas are always burnt." The mineral ash with which burning enriches the soil is for the most part unnecessary in Argentina, and the accumulation of humus through the natural decomposition of the dry herbage would be more valuable. Further, the dominant hard grasses of these pampas, *Stipa mendocina* and *S. tenuissima*, are preserved at

the expense of the better and more palatable species, especially the annuals. (Hieronymus, 1874. Reprinted 1945. pp. 29-30.)

In an interesting article on the improvement of natural grasslands, Falzoni, of the Brazilian Department of Animal Production, deplors the common practice of burning and describes fire as "Enemy No. 1" of organic matter. His view is that while there is usually an abundance of the mineral elements requisite for the nutrition of herbage plants, there is a practically constant deficiency of organic matter, and to this is attributed the inferiority of the vegetation. This author indicates more laborious and costly, but more satisfactory methods of improving such land, namely, the mowing of weed growth and foggage and its employment for mulching, and subsequently the gradual resowing of the land with better quality herbage. (Falzoni, 1936.)

Barros deprecates the burning of the native vegetation of the arid north-eastern lands of Brazil. (Barros, 1943.)

N. Vincent, also of Brazil, draws attention to the injury suffered by the botanical composition of pastures through "the abominable system of burning", and urges that rotational grazing should be more generally practised in order to avoid the necessity for firing. (N. Vincent, 1938.)

Hosseus, visiting the salt lands of Córdoba, Argentina, states that burning for the improvement of grazings reduces the proportion of certain plants, the palm *Trithrinax campestris* being noted as an example. (Hosseus, 1939.)

Rhoad, writing on land uses and trends in the Brazilian State of Minas Gerais, describes the effect of burning on the botanical composition of the natural grazings in the central region. "There is little or no mixture of the principal grasses in the zone. One encounters vast extensions of single species of grass. The lack of mixture is due to various factors. Of these the practice of burning is perhaps the most important, for the burning, which is done shortly after the return of the rains in the spring, is systematically controlled to favour one species while destroying others." (Rhoad, 1942.) Further information on the species respectively favoured and destroyed would be of interest.

"The scarcity of the vegetation" writes Rawitscher of arid South Brazilian grasslands "does not result from scarcity of water, but is a consequence of the annual burning off of these lands." (Rawitscher, 1944.)

In a survey of the animal husbandry of Guatemala, Work recommends a discontinuance of the burning of old grass. More valuable herbage species such as *Melinis minutiflora* and *Chloris gayana* could then be introduced and the indigenous species of *Desmodium* would reappear, augmenting the nutritive value of the herbage. (Work, 1945.)

Mendivil, writing of the Peruvian highlands, holds that burning does more harm than good. The poorest type of grass, *Stipa ichu*, may be induced thereby to provide young shoots, but they are of temporary duration only and the old grass, with large and compact roots, continues to monopolize the ground uselessly, a hindrance to grazing and a source of soil impoverishment. The burning of pastures composed of nutritive species is purely a work of destruction, wherein the short, tender grasses are the first to perish. (Mendivil, 1941.)

In a study of Uruguayan soils Quinteros, Arocena and Vercesi write: "It is common to observe that grasslands which were distinguished not more than thirty years ago for their fine and varied herbage have not only lost their best component species, but have developed a xerophilous type of vegetation." This condition is attributed to the common practice of burning. The belief, they say, that burning improves hard grazings and is economical, is mistaken, and the practice, if it continues generally, will create a grave problem for the Uruguayan grasslands. "After burning, if there is opportune rainfall, the pasture certainly presents the appearance of

having tender herbage ; but if the result is duly analysed, there will be determined the loss of innumerable species which are just those having the most superficial roots and forming the retaining framework of the humus soil." (Quinteros, Arocena and Vercesi, 1939. Quoted by Boerger, 1943.)

Costa Rican measures for plant protection envisage, among other things, the protection of valuable species that are often destroyed by burning. (Orozco, 1939.)

For the maintenance of soil fertility in Brazil, Menezes Sobrinho considers indispensable the prohibition of the wholesale burning of vegetation that is customary in many parts of that country. (Menezes Sobrinho, 1943.)

In Daireaux' Argentine agricultural classic, "Stockraising on the modern estate", first published in 1887 and now revised and reissued by R. M. Defradás, burning, as a general rule, is deprecated. (Daireaux, 1944.)

Diversification

Diversification, a measure of improvement relating to agriculture generally, is of importance with reference to grassland in that more diversification will tend to augment the number and area of the temporary leys, and increasingly to relegate the great natural grazings to the position of what is known in New Zealand as "store country." At the same time the amount of live stock kept will be increased, its type may be changed, and quite probably its quality will be improved. Dairying, at the present time much to seek in many parts of Latin America, should receive a considerable impetus through an increased amount of diversification.

The subject is practically new for the continent. It is true that there is a certain amount of diversification in, for example, the central region of Chile and in the immediate vicinity of the larger South American cities, where an increase in dairy farming tends to produce a more mixed type of farming. There also exist pockets of settlers who are obliged by the very conditions under which they live to practise a measure of diversification. Boerger writes : "On penetrating into the illimitable forest regions of the northern La Plata hinterland one encounters—in Argentina, Paraguay and southern Brazil alike—settlements of small colonists in the primeval forest who are largely relegated to a state of autarchy on account of the isolation of their holdings." (Boerger, 1938*a*.)

In general, however, diversification—as Tenenbaum (1943) says in regard to Argentina—is practically non-existent.

There have been some important references to it in recent literature, and encouragement on the part of the authorities is evident in some countries.

ARGENTINA AND DIVERSIFICATION

At the opening of the Second Argentine Congress on Agronomy at Córdoba on April 5th, 1943, the Under-Secretary for Agriculture made an impressive speech on the urgency of introducing a more diversified form of agriculture into Argentina. He stressed the increased costs, soil exhaustion and other disadvantages attending monocultivation or specialized crop production ; and the advantages, social, economic and agricultural, of greater diversification ; and made a plea for the establishment of research and experimental work on a scale more in keeping with the actual resources of the Argentine Republic. (Erro, 1943.)

In an address to the 58th National Cattle Show of the Argentine Agricultural Society in 1944, the Minister of Agriculture for Argentina urged the necessity of replacing one-sided stock raising or cropping by diversified farming, in the interests of the national economy and the individual alike (Mason, 1944) ; and in another speech, made to the Rural Society of the Chaco in the same

year, he stressed the desirability of growing a greater variety of crops in the Chaco region, which has suffered greatly from the lack of diversification. (*Noticioso, B. Aires. 1944b.*)

Tenembaum delivered an address to the Second Argentine Congress on Agronomy in 1943, in which he discussed diversification in relation to soil conservation, time and space in agricultural production, and the maintenance of economic equilibrium. With the exception of dairy farms in the province of Santa Fé, which have become fairly numerous in recent years, there is hardly any diversification in Argentina. Economic difficulties, unemployment in particular, ensue. Landholding systems, especially the preponderance of very large estates, are considered mainly responsible, and the desirability of studying the problem and of State assistance is stressed. (Tenembaum, 1943.)

At an earlier date Ito, a Japanese immigrant with nearly thirty years' experience of farming in Argentina, delivered a lecture to the Faculty of Agronomy of the University of Buenos Aires in which he advocated the substitution of cropping systems of temporary leys for the wasteful and soil-exhausting practice of growing cereals in constant succession without the use of fertilizers. He outlined rotations he himself had found successful, and considered that they should be employed by the cattle rancher as well as by the grain grower. Their advantages include not only the obtaining of a good yield of plant and animal products, but also the elimination of animal disease and the conservation of soil fertility. A system of mixed farming was considered safer and preferable to the high degree of specialization that at present characterizes Argentine agriculture. (Ito, 1939.)

The Argentine Province of Tucumán has suffered economically from an excessive reliance upon sugar cane cultivation. The Tucumán Agricultural Experiment Station, although it has necessarily had to devote a considerable amount of attention to the regional cash crop, has also—from its foundation in 1909 onwards—made a continuous study of other crops, and is endeavouring by educational methods to bring about a greater variety in the provincial cropping systems. At the present time, of the Station's 95 hectares of experiment fields only 18 are devoted to sugar cane. Introduced and indigenous herbage and forage plants occupy an important position among crops studied for their usefulness in the Province, and as a result many have come under current cultivation, notably winter lucerne No. 3 (*Medicago sativa*), clover No. 9, Rhodes grass, Sudan grass, elephant grass, different varieties of sorghum and of cowpea and other legumes. (Cross, 1944.)

In 1939 Schultz, also of the Tucumán Agricultural Experiment Station, foresaw that through the abnormal conditions imposed by the world war increased demands would be made upon the northern Argentine provinces not only for meat, but for other products and notably oil plants. He stressed the importance of a wider cultivation of the last-named and also of forage plants for periods of drought and cold. (Schultz, 1939.)

BRAZIL AND DIVERSIFICATION

Keeler and Lankenau write that in the Brazilian State of São Paulo and northern Paraná an increase in diversification is in evidence. New industries have been established as a result of replacing old coffee plantations by pasture land of fine grasses. The recent developments in diversification are ascribed to the soil ("chemically poor but physically excellent"), temperate climate, and the progressive spirit of the people of this region. Approximately 50 per cent of Brazil's total agricultural production comes from the zone in question, which covers, however, only about 3 per cent of the area of the country, and the varied nature of this production is seen from the following approximate percentages contributed to the total Brazilian output: coffee, 70; cotton, 65; citrus fruit, 40; maize, 25; refrigerated kill of cattle, 60 (São Paulo packing

plants). This region has also been playing an important part in the programme for the expansion of agricultural production into new areas in Brazil. (Keeler and Lankenau, 1941.)

CHILE AND DIVERSIFICATION

In Chile, the farmers and officials of the great central region are realizing—more than ever before—the necessity of diversifying the agriculture of their unusual country. “Even to-day, nearly every type of agriculture known to Europe and North America is to be found in Chile. There are grazing regions which are like those in the Alps of Europe and the Rocky Mountains of the United States; dairying regions like those of the Low Countries and Scandinavia, and of Wisconsin and Minnesota; wheat-growing regions like those of the Danube Basin of Europe and the Central States of the United States, though on a smaller scale; and even rice-growing regions like those in Italy and around the mouth and lower reaches of the Mississippi. . . . The agriculture of the country has a complex geographic and soils pattern which is eminently suited to an intensive rather than an extensive type of agriculture.” Thus writes Wilson (1945), who notes further that the trend towards diversified agriculture in Chile is necessarily gradual but the final result should be a higher net return per acre and a better standard of living for all. (Wilson, 1945.)

PERU, CUBA, AND THE DOMINICAN REPUBLIC

Other countries in which a trend towards diversification is noted are Peru, where the Government has created a commercial department in the Bureau of Agriculture and Livestock to facilitate marketing; Cuba, where a new law requires large sugar farms to divert a part of their land from cane to rice, maize, peanuts, beans and other food crops, the Ministry of Agriculture to give material assistance; and the Dominican Republic, where the war-time demand for rice, beans and similar food has hastened diversification. (*Agric. Amer.*, 1941, 1942, 1944.)

Rotational cropping

Closely allied to diversification is crop rotation, which also is yet to seek in most parts of South America. In many countries, however, the disadvantages of monocultivation have become all too apparent, and the practice of rotational cropping is being commended to the farmer in the various agricultural journals.

LONG-DURATION EXPERIMENTS

In Uruguay a long-duration cropping experiment has been in progress at La Estanzuela since 1917, wherein septennial, biennial and triennial rotations of different cereals, combined in one case with flax and in another with fallow, are compared with continuously grown maize, wheat and oats, and the superiority of the rotations is clearly demonstrated. For maintaining soil fertility, the septennial rotation is considered the best. Manurial trials connected therewith showed that the factor “rotation” is more effective than the factor “fertilizer” in improving yield, especially in wheat. Reports have been published on these cropping trials from time to time which furnish interesting data on the value of certain plants for preceding others, the susceptibility or immunity of different plants to the evils of continuous cropping, the important part played by weed invasion in the degradation of soil under a monoculture, and the relation of fungous attack to the continuous growing of a cereal in one place. (Boerger, 1928, 1938*b*, 1939*a*. Bonjour, 1935. Goetz, 1937. Noll, 1938.)

The above-named experiment, while it affords ample illustration of the value of rotation *qua* rotation, does not include any herbage ley; but in his recently published book Boerger has

emphasized the value of cropping systems in which *grazed* leys, either of lucerne or of herbage containing a good proportion of legumes, play a part. He speaks of progressive Uruguayan ranchers who are succeeding in augmenting their output both of animal products and of crops by means of a systematic alternation of these two branches of agricultural industry, to the great benefit of their land. (Boerger, 1943, Vol. 1, p. 430.)

It has been noted in Chapter 7 that ley farming, with certain important exceptions, hardly exists in Latin America. Forage and herbage leys are grown principally to cover seasonal shortages of feed or to supply wanting nutritional elements, but hardly for any part they may play in a cropping system or in conserving soil fertility. The assertion by Boerger just quoted indicates, however, that there are possibilities of future developments in this direction.

Other crop rotation experiments to which reference may be made are one that was begun in 1939 at the Brazilian Seed Production Station of São Simão in the State of São Paulo, in which maize and cotton are grown (*a*) continuously, (*b*) in rotation with legumes, in order to test the different effect on soil fertility; and another recently established in replicated quadrangular plots at the Curitiba Experiment Station, Brazil, from which it is hoped to obtain valuable fundamental data. One section of the last-named experiment is being allowed to revert to the natural plant cover. (Brazil, Min. Agric., 1940. Fischer, 1943.)

IN SUPPORT OF ROTATIONAL CROPPING

Some writers who have advocated rotational cropping may be mentioned here. In a Colombian Government pamphlet Barbosa recommended the use of *Vicia villosa* and *V. sativa* as green manure for exhausted soils and as components of cropping systems. "The practice of rotation," he wrote, "so important, so little known and therefore so little applied in this country, is one of the many factors which contribute to the complete use of the land." (Barbosa, 1932.) Klein, writing on soil conservation in Guatemala, stated that under the tropical conditions of the country it is imperative that not for a single hour should the soil be denuded of a close plant cover, and herein the important part to be played by the legumes and the necessity for rotational cropping were emphasized. (Klein, 1941.) Deger, also writing of Guatemala, stressed the necessity of growing legumes and green manure crops and of alternating annual or biennial cultures with five to eight-year crops such as cotton, in order to restore the humus that is of primary importance for tropical soils. (Deger, 1940, 1942.) The Guatemalan Department of Agriculture has published a leaflet by Argüello showing the relative requirements of different crop plants in the principal plant nutrients, in order to assist the farmer to plan suitable rotations. (Argüello, 1939.) In the official agricultural journal of Guatemala an article by Thorne recommending cropping with *Medicago sativa*, *Melilotus*, *Vicia villosa* and grasses for soil improvement was recently published. (Thorne, 1943.)

The Brazilian Ministry of Agriculture published in its journal a note on the advantages of rotational cropping that was based on a publication of Dr. Boerger's on this subject. (Brazil, Serv. Inf. Agric., 1940.) The Argentine Yearbook of Agriculture has been presenting educative articles on the subject. In 1941 Riveros wrote on the following aspects: the object of crop rotation, climate, soil, general technique, distribution of labour, marketing, tillage, weed destruction, control of disease, and quality of the products. He then discussed some cropping systems suitable for Argentina, with special reference to the position of lucerne. (Riveros, 1941.)

In 1942 the Department of Agriculture again gave a brief exposition of the principles governing crop rotation, with suggested successions for virgin land or old lucerne leys and for cultivated land in Argentina. (Argentina, Dir. Agric., 1942.)

Improvement of the natural grazings

The most intensive efforts in this direction are being made in Uruguay, the agricultural land of which consists preponderantly of such grazings. Boerger considers that the forage problem of Uruguay may best be met by concentrating on the improvement of the natural grazings and of the present system of extensive farming rather than on the further intensification of stock raising and therewith an extension of the temporary ley system. His view is based not merely upon the difference in the area concerned (fifteen million hectares of natural grazings as opposed to one and a half million hectares of sown leys), but also upon the findings of previous workers, upon the dangers attending the indiscriminate extension of arable farming with an accompanying removal of the protective sward, as exemplified in North America, and upon a comparison of the profits obtained from a lucerne area in Argentina producing beef only (no sheep) and a natural grazing area in Uruguay where mixed stock, with a preponderant production of sheep for wool, is kept. (Boerger, 1937*a*.) His argument, of course, refers to Uruguay only, a stock-raising country *par excellence*. The necessity for improvement is felt in other parts also. Rueda and Reyes have written on the problem in Colombia, Falzoni and others on Brazil. (Rueda and Reyes, 1941. Falzoni, 1936. F. P. Monteiro, 1938. N. Vincent, 1938.)

MEASURES FOR IMPROVEMENT. MANURIAL TREATMENT

On account of the vast areas concerned, ordinary manurial treatment and the use of synthetic fertilizers in particular appear to be impracticable for economic reasons. Writing of manurial trials in Uruguay, Boerger says that under present conditions in that country less costly means of improvement must be sought, although in exceptional cases green manuring through the growing of lucerne and even potatoes may be employed. (Boerger, 1935, 1938*a*, 1943, Vol. 1, pp. 500-2.) Falzoni recommends the mowing of weed growth and foggage and its employment for mulching in order to promote soil fertility. (Falzoni, 1936.) Several writers have drawn attention to the continuous withdrawal of mineral substances—without the making of any corresponding restoration—that has been taking place for some four centuries with an intensification in the nineteenth century; and Lerena has urged the salvage of bone for soil correction and has forecast the necessity of legislation to prevent the export of bones. Liming is also suggested for mineral-deficient lands. In Colombia a project is on foot for the conversion into fertilizers of bones, hides, hoofs and horns from a slaughterhouse (capacity one to two hundred head of cattle per day) to be used in restoring the badly depleted western llanos of that country. (Boerger, 1938*a*. Davies, 1940. Lerena, 1938. *Agric. Amer.*, 1945.) Quite general, also, is the recommendation of a greater encouragement and dissemination of legumes in the natural grazings for the promotion of soil fertility as well as more nutritive herbage.

FENCING

Fencing, introduced in the nineteenth century for the separation of lands and herds, has now become recognized as a means of improving grazings and grazing practice.

In Colombia it is appreciated that some of the principal defects of animal husbandry in that country—inadequate care of stock, insufficient hygiene, poor selection, imperfect breeding, poor use of grazings—are due to the lack of fencing, and in order to encourage a greater division of the grazings standardized barbed wire has been made available at low prices through the Government Department of Agricultural Credits. (Rueda and Reyes, 1941.)

At the Puno Model Farm in the highlands of Peru, fencing—from thirty to fifty miles of all-iron wire, with a special apparatus for tautening—is considered of enormous importance not only for the quality of the flocks but also for that of the sward. Carrying capacity has been greatly enhanced, and rotational grazing is made possible. (Stordy, 1938.)

Mendivil regards fencing as a primary necessity for the improvement of natural grazings, wherein he also is considering the highlands of Peru. Exhausted, over-trampled grazings should be strictly reserved or fenced off for three or four years and kept free of all kinds of animals, so that the plants may seed three or four times in succession and a new, close plant cover may be formed. (Mendivil, 1941.)

At an earlier date Spangenberg in Uruguay emphasized the essential nature of fencing. "The rancher must realize that the cost of the wire fencing required for the division of his grazings represents the insurance premium for the maintenance and improved productivity and nutritive quality of his lands." Herein Spangenberg, like Mendivil and other advocates of fencing, urges the practice of rotational grazing. (G. E. Spangenberg, 1930.) Boerger in his recent book has presented an exposition of the original Hohenheim system of rotational grazing. (Boerger, 1943, Vol. 2, pp. 1,001-4.)

For dairy farms in São Paulo, Brazil, Monteiro recommends the division of grazings into pastures of approximately 30 alqueires, each containing, if possible, some high and some low ground, whereby varied types of herbage are assured for stock and rests of three or four months' duration can be given to the grazings. (An alqueire is a São Paulo land measurement, 24,200 sq. m.; the author states that the average carrying capacity of the Pindamonhangaba region does not exceed two head of dairy cattle per alqueire.) (F. P. Monteiro, 1938.)

N. Vincent, also writing for the state of São Paulo, Brazil, stresses the importance of subdivision into small pastures and the practice of "an intelligent rotation." (N. Vincent, 1938.)

Quite recently the advantages of electric fencing have been described in the Yearbook of the Argentine Ministry of Agriculture. It is recommended especially for use in subdivision into paddocks, as being quickly and easily transportable, and is said to be acquiring a considerable amount of popularity in Argentina on account of its economy and value for enclosing all kinds of animals, especially pigs. (Cano, 1943.)

CULTIVATION

Disking, harrowing, or—in extreme cases of heavy weed dominance—ploughing for improvement are fully described by Spangenberg, the cultivation to be followed occasionally by resowing. The time of harrowing must be carefully chosen. It should not be done when weeds are setting seed, but if possible at the end of winter or beginning of spring when (in Uruguay) the temperature is beginning to rise and there is generally rainfall, climatic conditions which augment the favourable action of harrowing. (G. E. Spangenberg, 1930.) Mendivil recommends harrowing or scratching, possibly by tractor-drawn implements, for the aeration of the soil and improvement of its water relations, care being taken—especially in highlands such as those of Peru to which the author refers—not to expose the roots of the herbage to the cold. If still further improvement is desired, island guano or well-rotted farmyard manure may be applied, but in moderation in order that the roots are not burnt. All such measures should be taken in months in which the rains begin, so that the action of harrow and of fertilizer, if any, may be completed by that of the rain. Harrowing may also be done between May and June (the period when in the Peruvian highlands grass sets seed) if it is desired to harrow in seed of the natural herbage or to introduce foreign seed into an exhausted grazing. (Mendivil, 1941.) N. Vincent (1938) also recommends harrowing in the rainy season. Falzoni recommends various forms of cultivation in order to aerate the soil. (Falzoni, 1936.)

RESOWING

Falzoni (Brazil) recommends that small areas, approximately two hectares in size, be set apart here and there for special cultivation (ploughing and disk harrowing, or disk harrowing

only) and the growing of grasses selected with a view to their suitability for the region concerned. These areas would furnish a nucleus of material for the resowing of larger areas. The sowing of large areas should be done by broadcasting on horseback. When the disking or harrowing of larger areas is impossible, Falzoni considers careful cleaning by scythe or hoe to be indispensable. Whenever possible some legumes should be included among the plants sown, and care should be taken to choose for gradual introduction the more valuable grasses. There is no point, he maintains, in wasting time over such grasses as *Andropogon tener*, *A. virginicus*, *A. condensatus*, *Imperata brasiliensis* and suchlike; efforts should be concentrated on the encouragement of species such as *Melinis minutiflora*, *Hyparrhenia rufa*, *Chloris gayana*, *Meibomia adscendens*, a well-known Brazilian pasture legume which is resistant both to drought and trampling, and *M. barbata*.

Mendivil, referring to the Peruvian highlands, approves of resowing harrowed and manured lands with the collected seed of valuable indigenous grasses such as *Bromus catharticus*, *Festuca dissitiflora*, *Poa annua*, *Paspalum* spp. and *Muehlenbergia fastigiata*. If introduced foreign grasses are used for the purpose, good manuring must follow sowing, but this is not necessary in the case of the legumes. (Mendivil, 1941.)

A method of pasture renovation in use at the Pindamonhangaba Experiment Station in the State of São Paulo, Brazil, was reported in 1939.

The Station has abandoned the practice of renovating pastures by mowing. Experience proved it not merely to be expensive, but to give ephemeral results only, for weeds—especially if mown in the period August to February—sprout with increased vigour within a few days, and ant-hills, when burnt and then destroyed with a spade, reappear in an average percentage of fifty. The following new process has been adopted. Ant-hills (numbering approximately thirty per alqueire) are destroyed and any necessary clearing is done, the pastures are ploughed and harrowed, dressed with bone meal (800 kg. per alqueire), again harrowed, and sown with maize (38 kg. per alqueire). The maize is thinned out and then earthed up, and, in the furrows left between the rows of maize by the latter process, grasses are sown or (more frequently) grass shoots are planted, without disturbing the earth about the maize. The grasses are sown or planted in pure cultures; the size of the area planted with any species is directly proportional to its palatability and inversely proportional to its capacity for invasion. The species chosen have different growth periods. There is thus ensured a supply of herbage for all seasons of the year, and an avoidance of monotony. The following is the planting scheme adopted by the Station, the first area being that at the highest altitude, the rest following in order of descent. *Melinis minutiflora*, 1 alq.; *Panicum maximum*, 2 alq.; *Hyparrhenia rufa*, 1 alq.; *Panicum maximum* var. *gongylodes*, 2 alq.; *Pennisetum purpureum*, 1 alq.; *Chloris gayana*, 1 alq.; *Paspalum notatum*, 2 alq.; *Brachiaria plantaginea*, 2 alq.; *Pennisetum clandestinum*, 2 alq.; *Panicum purpurascens*, 2 alq. (1 alq.=24,200 sq. m.).

A detailed account of the costs of each process, including the harvesting, carrying and threshing of the maize, shows that there is a substantial balance in hand after the maize has been sold and the improvement completed.

(Salgado, 1939.) This method would hardly seem to be appropriate for large areas, however.

Much of the work at present in progress in Chile, Uruguay and Venezuela is concerned with the trial, adaptation, reproduction, and occasionally with the actual breeding of herbage species for eventual dissemination in and improvement of the natural grazings.

TREES

The preservation or plantation of tree growth is recommended by Falzoni, especially in the higher parts of grazings, for the beneficial effect of trees on climatic conditions and the prevention of erosion (Falzoni, 1936), and by N. Vincent for shade and shelter for stock (N. Vincent, 1938). Carneiro, of Minas Gerais, Brazil, also stresses the value of shelter belts of trees. (Carneiro, 1942.) At the same time the encroachment of scrub is undesirable. In some parts of Brazil attempts are made to control scrub formation by the process of cutting back bushes and small trees. This practice, known as "roçar", is very laborious and has to be done every year. The theory is that by constant reduction the scrub should die out, but in practice it is strengthened by regular pruning. (Pheysey, 1947.)

CONSERVATION

Although periodic shortage of feed is a constant and lamentable feature of the cattle industry in South America, the practice of conservation is as yet little known, especially where the hot regions are concerned. Exceptions are to be found in Argentina, where haymaking and ensilage are more or less common in the pampas of Buenos Aires and the Provinces of Santa Fé, Córdoba, etc. (Burkart, 1945*b*), and in Uruguay and Brazil, where ensilage is being encouraged by propaganda and demonstration. In other countries, however, such measures are still infrequent, although it has been calculated in the case of Chile, for example, that the practice of fodder conservation would enable the number of livestock now maintained to be increased by over 30 per cent. (Castro, 1941.)

ENSILAGE. BRAZIL

In several countries official propaganda is encouraging the farmer to undertake haymaking and ensilage, and in Brazil subsidies are granted for the erection of silos. Interest in the ensilage of green fodder for use in the dry season is increasing in Brazil. In 1941 silos erected with the aid of Government grants had a total capacity of over five thousand tons. One municipality alone (Machado, in Minas Gerais) was said to possess over seventy silos, constructed or in course of construction. (*Bol. Min. Agric., Brazil, 1942d.*) The Brazilian Government contributes a certain sum per tonnage capacity, varying according to the type of silo and payable when the building is two-thirds accomplished, the silos to be built in accordance with conditions laid down by the Department of Animal Production and to be of not less than 20,000 kg. capacity in the case of tower types or 10 tons in the case of pit types. (Alves, 1935.) The Government has further provided assistance in the publication of a copiously illustrated book by Alves and da Silva, which deals with all aspects of the ensilage question with special reference to the needs of the Brazilian farmer.

Crops considered suitable are maize, which is held to be the best, then sorghum, sugar cane, *Hyparrhenia rufa*, *Brachiaria plantaginea* and other grasses, pasture herbage, lucerne, clover, groundnuts (the leaves), cowpeas, velvet beans, an indigenous legume (*Phaseolus panduratus*), grass-legume mixtures, sweet potatoes, sunflowers. Of the silos described, the authors consider the hillside silo to present the ideal type. This, of cylindrical form and constructed in the side of a hill or embankment, does away with the necessity of using cement in building and of employing an elevator for filling it. Filling is done from the top of the hill or embankment, the silage being removed on the lower side. Its one disadvantage is that it is not always possible to locate it close to the feeding place. Essentials of success are (1) that the silo be airtight; (2) that, on account of the normal fermentation produced by the admission of air to a silo, emptying should be carried out at the rate of one layer of silage per day, the minimum thickness of which should be 5 cm. in cold weather and 7.5 cm. in summer; (3) that the diameter of a silo should be determined in relation to the minimum number of animals to be fed; and (4) a silo should always be emptied in horizontal layers, from the top downwards. (Alves and Silva, 1936.) Mendes commends maize as a silage crop, to be used when the cobs are fully formed but still green and tender. (Mendes, 1944.) In the State of São Paulo conditions as a rule necessitate a more intensive type of farm organization than is customary elsewhere in Brazil, and ensilage is here of special importance. (Reveilleau, 1938.)

ENSILAGE. URUGUAY

In Uruguay much interest has been awakened on the subject of ensilage, especially in the dairying districts.

Carbonell Más, a scientist attached to an Uruguayan dairy company, gave an account of silos in existence in 1934, of methods of construction, filling and use, and of costs and results. The type found most useful and economic in Uruguay is the "parva" silo, part trench, part stack, a finding confirmed later by Nores. Under the supervision of the National Commission

for the Forage Problem, 131 silos with a total capacity of 8,500 tons were erected during the years 1936 to 1941. As in Brazil, maize is the leading silage crop and comprises 49 per cent of the tonnage just mentioned. A curious runner-up in this respect is the thistle, a troublesome Uruguayan weed which comes second on the list with a percentage of 31. Thistle silage has been made on ranches where the weed has been too dominant, and the double object of cleaning the land and obtaining nutritive silage has been attained. Two species of thistle are concerned, *Cynara cardunculus* for the most part, and *Silybum marianum*. Nores reports that these species, especially the second, have, when ensiled, approximately the same nutritive value as a lucerne mixture, and a higher content of protein, calcium and phosphorus than have oats, barley, wheat, maize and sorghum. Other plants ensiled in Uruguay from 1936 to 1941 are the following (the figures represent percentage of the 8,500 tons): maize plus groundnut, 10.1; thistles plus oats, 3.4; oats, 2.7; Grohoma sorghum plus soybeans, 1.2; Sudan grass plus soybeans, 1.2; Grohoma sorghum, 0.8; ryegrass, 0.4; lucerne, 0.2. This silage has been examined from time to time and studies of the nutritive value have been made by Montedónico and others. Montedónico finds the silage to be more nutritive than hay. (Carbonell Más, 1934. Montedónico, 1938. Nores, 1938. Boerger, 1943, Vol. 2, p. 1,011.)

ENSILAGE. ARGENTINA

In Argentina, according to Burkart, ensilage is now a common practice. Two types of silo are used. (1) Subterranean or semi-subterranean silos, excavated from the ground. These are used for lucerne, generally the first cut which contains many weeds such as thistles and would not give good hay. The practice assists also in the control of the thistles, namely, *Carduus pycnocephalus*, *C. nutans*, *Silybum marianum*, etc., which are very aggressive. (2) Tower silos of materials such as enforced concrete. These are normally found only on the model dairy farms which supply milk to towns such as Buenos Aires, Tucumán, and others. (Burkart, 1945b.)

The Argentine Ministry of Agriculture recommends in its Yearbook the use of the "parva" silo, part trench, part stack, the semi-subterranean silo to which Burkart has referred, and gives some information on its use. (G. J. Miranda, 1942. Argentina, Dir. Agric., Lab. Ing. Rur., 1942.)

ENSILAGE. CHILE, VENEZUELA

A part of the general effort to improve the fodder supplies of Chile is the encouragement of ensilage. Buchner, of the Experiment Station of the National Society of Agriculture, has published an article on the principles and advantages of ensilage. He considers that both silage and hay should be available on the modern estate. He enumerates three types of silo, the tall, built silo; the popular semi-trench, semi-stack type; and the pit silo, which—although nutrients are more easily lost than in other types—is cheap. (Buchner, 1943.) In 1941 the Chilean agricultural journal *El Campesino* published information referring especially to the ensilage of grasses and legumes, taken from a leaflet of an agricultural implement manufacturing company. (*Campesino*, 1941a.) Villamediana has written on the urgency of ensilage for Venezuela, where the shortage or absolute lack of herbage in summer renders the conservation problem one of vital importance for the country's meat and milk supplies. (Villamediana, 1943.)

HAYMAKING

Haymaking appears to be if anything less popular than ensilage, but efforts to encourage its adoption are not wanting. The making of lucerne hay in Argentina has been mentioned. (Parodi, 1942d.) According to Burkart, haymaking is common in the great lucerne area of Argentina. "Everywhere there may be seen the great haystacks, sometimes as much as 8 metres high." (Burkart, 1945b.)

In Brazil haymaking is commended to farmers, especially in the State of São Paulo, where the dry season begins in June and is sometimes prolonged to November. Sampaio, of the Directorate of Animal Industry, has discussed technique. The best time for mowing in most cases is when the plants are in flower, but certain grasses should be cut as soon as they are high enough to mow. Among these are *Hyparrhenia rufa*, *Pennisetum purpureum*, *Panicum maximum* and *Melinis minutiflora* (which gives three or four cuts a year). *Chloris gayana*, however, should be mown just as the flowers are beginning to form. The quality of legume hay (lucerne, cowpea, velvet bean, etc.) may be much improved by drying partly in the field, and afterwards in the shade of roughly constructed sheds, wherein care must be taken to prevent fermentation. Chemical analysis of the principal meadow plants is given in a table. (Sampaio, 1935.) Texeira Mendes recommends for haymaking the grasses *Hyparrhenia rufa*, *Chloris gayana*, *Melinis minutiflora*, *Pennisetum clandestinum* and *Panicum purpurascens*, and outlines the management of a meadow destined to be cut. Mowing should be done before flowering. (Mendes, 1944.) Monteiro and Kok also recommend haymaking and ensilage for São Paulo. (Monteiro, 1938. Kok, 1943.)

Haymaking is likewise recommended in Chile. The *Campesino* has published information on hay baling (*Campesino*, 1942) and Buchner has discussed the time of mowing as it affects the protein content of hay with special reference to lucerne, clover, and soybeans. (Buchner, 1944.)

Argüello, Guatemala, considers haymaking the most economical and profitable form of conservation for the higher lands of his country. Mowing should be done before the grasses fruit, drying should be done in swathes on the ground, and the hay should be carried when the moisture content is neither more than 25 nor less than 15 per cent. Plants recommended are *Setaria setosa*, *Pennisetum clandestinum*, *Setaria geniculata* and the exotic *Chloris gayana*, and the legumes *Medicago sativa*, *Cajanus indicus*, and *Trifolium repens*. (Argüello, 1938, 1939.)

The strong insolation of tropical conditions constitutes an actual obstacle to successful haymaking in certain parts of Latin America, and often necessitates the use of the roughly constructed sheds to which Sampaio has made allusion. (Sampaio, 1935.)

ARTIFICIAL DRYING

Only an academic interest appears to be taken in artificial drying as yet, but the subject is being studied. Sobrero has described three types of drier in the Argentine Ministry's Yearbook, and in Chile an account has been published of experiments conducted at Jealott's Hill, England, from 1932 to 1935. (Sobrero, 1940. *Campesino*, 1941*b*.)

CHAPTER 12

BOTANICAL RESEARCH

It is only possible here to make brief reference to the botanical research underlying grassland investigations in Latin America, and that solely to more recent publications. For information on the earlier work the reader is referred to Blake and Atwood's "Geographical guide to floras of the world," 1942.

Floras

A floristic work published within the last two decades that is especially helpful to the student of South American agrostology is the late Pio Corrêa's "Dictionary of the useful plants of Brazil", 1926 and 1930. It contains a veritable mine of information, especially in regard to the grasses. The economic and nutritive value of the various plants is dealt with, in addition to the botany. A valuable feature is the indication of the different vernacular names in use in different parts of the continent.

The present use of vernacular names is chaotic and constitutes a very real obstacle to a comprehension of the South American grasslands. Allusion to the poverty and confusion of the popular nomenclature is made by Rosengurtt in a recent publication on Uruguayan pastures. For example, the name "flechilla" is applied to some forty species of *Aristida*, *Piptochaetium* and *Stipa*, while "cola de zorro" (foxtail) is applied to eleven species, seven genera being concerned, with more or less frequency. There are in addition a large number of supplementary names of exclusively local or even personal use. (Rosengurtt, 1943.) The Imperial Bureau of Pastures and Forage Crops at Aberystwyth is attempting to compile a glossary of the popular names applied to the grassland plants of Latin America, and it is hoped to publish this in due course.

Unfortunately Pio Corrêa's profusely illustrated and copious work was cut short at the end of the second volume through the death of the author. The material is arranged in alphabetical order of the common Brazilian plant names, and the author had only reached the letter E. This ensures, however, that most of the grasses are included under the word "Capim," and the work, even in its unfinished condition, constitutes an indispensable tool for the study not only of Brazilian plants, but of South American botany generally. (Corrêa, 1926 and 1930.) The decision of the Brazilian Ministry of Agriculture to publish a completion of this work is greatly to be welcomed. It is expected that Volume 3 will appear in 1947.

Attention is drawn to a catalogue of the Venezuelan flora, newly published by Pittier and collaborators (1945).

Legumes

The position of the Leguminosae in the flora of South America is of immense importance. It is one of the richest plant families in that continent. In Argentina alone there are over 500 species growing wild and profusely distributed throughout all the phytogeographical regions of the Republic. Nevertheless the South American natural grazings are deficient in legumes, a fact which lies at the root of certain nutritional deficiencies. A study of this family is thus of much interest for grassland research, and especial value is attached to the work of Burkart in Argentina and that of Ducke in Brazil. Happily Professor Burkart's work on the Argentine legumes, pursued since his graduation in 1928, has now been embodied in a volume published in 1943 and entitled "The wild and cultivated legumes of Argentina", wherein not only the systematic but the economic aspects of the several species are treated. (Burkart, 1943.) A glance at the list of some of the articles published before the appearance of this book shows that Burkart's output is large.

An article of special interest was published in 1941 on *Phaseolus vulgaris* and *P. lunatus*, species which, formerly considered to have come from Asia, are now generally admitted to be of American origin. Burkart has repeatedly collected in northern Argentina wild plants of these two species which differ distinctly from the cultivated types, namely, *Phaseolus vulgaris* in the sierras of Tucumán and Jujuy, in the humid valleys at altitudes of 15 to 18 hundred metres, and *P. lunatus* in Misiones and Jujuy. *P. vulgaris* is a late, annual, twining plant, with fruits and seeds smaller than in the cultivated types. No fully mature seeds have yet been collected. These wild plants are considered to be of genetic as well as systematic interest. (Burkart, 1941a.)

Ducke has done a great deal of exploration on behalf of the Brazilian Government, principally in Amazonia, and there appeared in 1939 a systematic study by him of 785 species of the Leguminosae of the great forests of that region. The Acre and the north of Mato Grosso are as yet practically unexplored, and Ducke considers that the actual number of species of Leguminosae contained in the Brazil Amazon region is probably not less than 900. In addition to classifying the species enumerated, descriptive notes and information on the distribution and uses of the respective plants are presented. The majority of the species are trees, but there are also a large number which are used as green manure or as forage plants, and some which are considered poisonous. (Ducke, 1939.)

Reference to some other articles of Ducke's will be found in the list of literature.

Other writers on the legumes are Herrera (1939a, 1941) for Peru and the Department of Cuzco in particular; Malme (1936a) for *Lathyrus* in the south of Brazil; and Amshoff (1939a, b), who has written on the Leguminosae of Surinam. Daniel (1940) has presented marginal notes to Santiago Cortes' "Monograph of the Leguminosae of Colombia"; Gunckel (1936) has written on "Adventitious legumes in Chile"; Sampaio (1932), in an article on the flora of the State of Pará, Brazil, has devoted forty pages to Leguminosae collected on the river Cumina and the region of the Trombetas, 75 genera being concerned; Hoehne (1938, 1940) has also written on the Leguminosae of Brazil. Clos has studied *Trifolium* and also types of *Arachis hypogaea* cultivated in Argentina, with a key for their identification (Clos, 1936, 1939a, b); and Pittier (1944) has recently published a study of the Papilionaceae of Venezuela (eighty genera).

Studies like the foregoing may help to solve two important problems: (a) the best types of indigenous legume for encouragement in the natural grasslands, at present deficient in proteins; and (b) which tree and shrub legumes are actually eaten by stock, and which should be encouraged or discouraged respectively.

Grasses

The foundation of all systematic study of the South American grasses is undoubtedly the work of Arechavaleta, who published at Montevideo from 1894 to 1899 the results of the observations of a lifetime. Of those who have built up on his work, the principal modern writer is L. R. Parodi of Argentina. Parodi, like his predecessor, is not only a systematist but incorporates in his work the ecological and also the agricultural view. He has published a very large amount of material, mainly in the form of articles and lectures, and it is much to be hoped that in due course his research will be embodied in book form. It is impossible within the scope of these lines to review his work, and reference must be made to the list of literature. An early book, published in co-operation with Reichert and Trelles in 1923, gives information on the nutritive value of the principal Argentine grasses.

Writers who have published articles on the Argentine grasses are Elisa G. Nicora (1939, 1940, 1941), Lahitte (1939), and Valencia (1937, 1941).

In Venezuela work on the systematics of grasses, and to a certain extent on their nutritional value, has been done by Henry Pittier (1926-1942) and by his student Zoraida Luces (1940-1942).

In Chile Rebeca Acevedo (1937, 1938) has written on the taxonomy of Chilean grasses, as has also C. Muñoz Pizarro, who has published a bibliographical index of the grasses of Chile (1941).

Mille published in 1929-30 a posthumous work of Father L. Sodiro's on the tribes of the Agrostideae and the Aveneae in Ecuador. This work has recently been reprinted. (Sodiro and Mille, 1929-30, 1945.) Itié (1939) has published information on the introduction and distribution of *Panicum purpurascens* in Mexico.

Systematics

An exposition of the new systematics has been given by H. Monteiro, Brazil (1942). Professor Apolinar María is compiling a glossary in which the fauna and flora of Colombia are listed and identified. This work, as yet incomplete, is illustrated by coloured plates and includes notes on the literature and on the history and uses of the species concerned. (Apolinar María, 1937-45.)

Attention also should be drawn to the work of Herter on the Uruguayan flora, work which contains information on the grasses and legumes. Three supplementary parts to the author's "Florula Uruguayensis" have recently been published.

Botanists from the United States who have written on the grasses of South America include A. S. Hitchcock, Agnes Chase, J. R. Swallen, C. L. Lundell, and H. N. Vinall.

Sandwith's studies of the flora of tropical America, published in the *Kew Bulletin*, should be mentioned.

European writers who have been concerned with the systematic botany of South American grasses and legumes include Bornmueller (1934), Pilger (1933-1944), Diels (1937, 1938), Asplund (1939), Henrard (1939, 1940, 1945), Pulle (1938, 1939), Suessenguth and Beyerle (1934, 1939), Burret (1937), Cufodontis (1932-1935), who wrote of the results of the Austrian biological expedition to Costa Rica in 1930, and Cuatrecasas (1936), formerly of Madrid, now of Colombia.

Morphology, physiology, and cytology

Sampaio (1930) has studied the foliar structure of the Gramineae from the taxonomical point of view. Physiological studies of South American plants are being carried out by Rawitscher and his staff at São Paulo, Brazil (1937-1944). Villagran Prado in Mexico (1941) has studied the effect of insulin on the plant cell; Sivori (1941) and Fina have separately studied flowering and pollination in *Helianthus annuus*, the second author studied also floral movements in this plant (Fina, 1943). Reichert and Paulsen (1934) have examined the effect of ultra-violet radiation upon germination and the first vegetative period in some seeds; and Almeida and collaborators (1941) have made investigations on the inhibitive action of the juice of *Solanum lycopersicum* on the germination of seeds and the growth of plants, including some forage plants. Canel and Sivori have published studies on photoperiodism. (Canel, 1937, 1938. Sivori, 1940, 1944.) Fina and Clos (1941) have recorded the phenological behaviour of perennial plants cultivated near Buenos Aires. Caryological studies of the grasses have been presented by Andrés (1941), Perak (1941), and Saura (1943).

Exploration

Phytogeographical and floristic exploration forms a very important part of South American botanical research. Reference has been made in preceding chapters to work of this nature by Martius, Warming, Lindman, Ducke, Bouillenne, and von Luetzelburg for Brazil; by Weberbauer for Peru; Hieronymus, Hauman, Parodi, Frenguelli, Monticelli and others for Argentina; and by Ochoterena for Mexico; and to similar studies. The University of Tucumán has done much service to the botanical research of Argentina in publishing a reprint (1945) of Hieronymus' study of the

vegetation of Tucumán, which originally appeared in 1874 but had by now practically ceased to exist. The work is of great importance as forming the basis of all subsequent phytogeographic and systematic study of that part of the Argentine Republic. Of basic importance also for the study of Argentine vegetation is the work of Hauman.

There should also be mentioned the exploratory work that is being carried out by the staffs of scientific institutes, by the staffs and students of various Universities, and by Government Departments. Examples of the first-named are the explorations made by the staff of the Botanic Garden and of the National Museum at Rio de Janeiro, and by Ochoterena and his collaborators at the Biological Institute, Mexico. Of University work there may be cited that of Solís and Paredes at the Central University of Ecuador; of Hosseus at the University of Córdoba, Argentina; and of Cárdenas at the University of Cochabamba, Bolivia. Reference has already been made to Government work in this direction, such as Ducke's Amazon tours and the studies of the National Commission on the Forage Problem in Uruguay. Brazilian studies of the hinterlands of Mato Grosso and elsewhere should also be noted.

An ecological monograph by Castellanos and Pérez-Moreau classifies the vegetation of Argentina and of adjacent regions of Uruguay, Paraguay, Bolivia and Brazil in "provinces" (Antarctic, Patagonian, Andean, etc.). A large number of excellent photographs illustrate the different types of vegetation, and those of the grasslands are of much interest. (Castellanos and Pérez-Moreau, 1944.)

Quite recently F. Verdoorn has published in the United States a symposium of articles by various authors on "Plants and plant science in Latin America". This book contains, although in somewhat fragmented form, a wealth of reliable information on the plants and plant industry of South and Central America. (Verdoorn, 1945.) The symposium includes an outline of the phytogeography of Latin America by A. C. Smith and I. M. Johnston; a history of botanical exploration in the continent by F. W. Pennell; a useful list of plant science periodicals by P. L. Guest; and an account by Rojas and Carabia of the vegetation of Paraguay which is of much interest to the grassland worker (see *Herb. Abstr.* 16. Abs. 577. 1946).

Much work by individuals, all of which has contributed valuable information on the South American flora, is noted in the list of literature at the end of this Bulletin, which does not, however, claim to be exhaustive.

CHAPTER 13

CO-OPERATION, RESEARCH AND GOVERNMENT ACTION

Within the last two decades there has been a great awakening in Latin America to the urgent need for scientific study of the natural resources contained in the vast lands of the southern continent. A happy feature of this awakening is the spirit of co-operation which distinguishes it. Not only has there been renewed activity on the part of the scientists and scientific institutes and increased support on the part of the Governments, but joint Congresses and co-ordinated action have revealed a high degree of professional solidarity which augurs well for the future.

Congresses

The following are some recent Congresses at which subjects of interest to the grassland worker have been ventilated.

FIRST SOUTH AMERICAN BOTANICAL CONGRESS

This Congress was held at Rio de Janeiro in 1938 under the patronage of the President of the Republic of Brazil and of the Minister of Agriculture, the President being Dr. Campos Porto, Director of the Institute of Plant Biology. Its principal aims were the establishment of effective collaboration between the botanists of South America, the consideration of means of protecting the flora of that continent through the creation of national parks, forest reserves, etc., and the organization of a systematic catalogue of the South American flora. Nine sections of the Congress studied various aspects of botanical research, including physiology, genetics, ecology and applied botany, and excursions were made to regions of botanical interest in the vicinity of Rio de Janeiro. Papers presented to this Congress and the ensuing discussions have been published in its three-volume *Anais*. (*Anais*, etc., 1938.)

EIGHTH AMERICAN SCIENTIFIC CONGRESS

This Congress, held in Washington in May, 1940, was attended by a large number of representatives of the various Latin American countries, who played an important part in the organization, addresses and debates of the Congress. An English translation of the full text of Dr. A. Boerger's paper on "Uruguayan research on forage problems", which includes a bibliography of much interest to grassland workers, has already been published. (Boerger, 1940.) Other papers of interest, delivered to the Section on Agriculture and Conservation, were those presented by Ordeñana on erosion and soil conservation in Ecuador, by Guérin and Alarcón on erosion and soil conservation in Chile, to all of which allusion has already been made (see pp. 183-98), and several other papers connected for the most part with soil conservation questions or with general agricultural technique in South American countries.

SECOND CONFERENCE OF THE ARGENTINE SOCIETY FOR THE STUDY OF THE NATURAL SCIENCES

This Conference was held in the town of Mendoza in 1937, the first Conference having taken place in 1916. The Conference is fully reported in *Physis*, Vol. 13, No. 45, 1943; and a brief report on papers read to the Applied Science Section was given in *Rev. argent. agron.* 4. 1934-6. 1937.

They include the following: Clos, E.C. Types of ground-nut (*Arachis hypogaea*) cultivated in Argentina and their geographical distribution in that country. Fifteen cultural varieties were distinguished, morphologically distinct, characterized by habit, the quantity of seeds per fruit, the colour of the tegument, and the size of fruit and seeds. Prado, L. de, and Dastugue, H. Basso. Study of *Astragalus chilensis*, a poisonous plant of the Neuquén. Mutinelli, A. An interesting indigenous legume (*Desmodium cuneatum*) in Misiones. Parodi, L.R.,

and Pastore, Ada J. Cultivated plants of economic importance represented in the indigenous flora of Argentina. Autochthonous material worthy of improvement was indicated, the genera listed including *Oryza*, *Hordeum*, *Phaseolus* and *Daucus*. Guíñazu, R. Projected creation of natural reserves in the province of San Luis. Burkart, A. Contribution to phytotechnical work on lucerne. The author's experience in the improvement of lucerne has indicated the frequency with which natural hybridization takes place and the possibility of obtaining in the F1 generation hybrids of greater productivity.

FIRST CONFERENCE OF BRAZILIAN PHYTOPATHOLOGISTS

This Conference was held in 1936 and its report contains thirty articles, some of which are of interest for grassland research. The Congress was under the patronage of the Brazilian Minister for Agriculture and the Presidency of Dr. A. Bitancourt. A report on its activities is presented in a special number of *Rodriguesia*, 1937.

FIRST ARGENTINE CONGRESS ON AGRONOMY

This Congress, held at Buenos Aires under the Presidency of Engineer J. B. Marchionatto in 1941, was organized by the Argentine Society of Agronomy and the Proceedings, containing abstracts of the papers presented, are published as a Supplement to the *Rev. argent. agron.* Vol. 8, 1941.

The Congress was of international character, for the Republics of Brazil and Chile supported it and a large number of delegates were sent by the Republic of Uruguay and its scientific institutes. The Minister of Agriculture for Argentina presided over the inaugural session of the Congress and in his opening address outlined achievements of agricultural research in the Argentine and aims for the future.

Engineer Marchionatto referred to projected legislation for dealing with erosion and preventing the destruction of forests, and to efforts to encourage the production of home-grown seed.

An important feature of the Congress was Professor Lorenzo R. Parodi's address on the organization of agricultural research in the Argentine Republic. Reference will be made in another part of this chapter to the address and to the action subsequently taken by the Congress.

The greater part of the Congress Report is occupied by abstracts of the papers presented. The first section deals with problems of soil science, and includes papers by A. Arena and J. R. Guíñazu on the structure of soils in the Pampean region where erosion has taken place, and a study by A. Arena, M. O. Betancur and R. Ribeiro of the patches of degraded, sterile soil found in Uruguay and known as "blanqueales" or "white patches."

Other abstracts presented include those noted in the following list. Baez, J. R.; *Chloris distichophylla*. Baez, J. R.; Two aspects of the vegetation in the north of San Luis. Part 2. Forage plants and weeds. Burkart, A.; The existence of wild races of *Phaseolus vulgaris* and *P. lunatus* in northern Argentina. Burkart, A.; Grassland analysis by the point method of Levy and Madden. Canel, M.; The photoperiodic response of plants and its application to phytotechnology. Dellazoppa, J. G.; The uniformity of selected varieties. Etchecopar, J. A.; Relation of time of sowing to yield in different varieties of maize grown at the Pergamino Experiment Station. Etchecopar, J. A.; and Sivori, E.; Some aspects of sunflower breeding. Fina, A. de, and Clos, E. C.; Phenological behaviour of the perennial plants cultivated in the vicinity of the city of Buenos Aires. Observations made in 1940. Gomez, M. M., and Quevedo, J. M.; Some observations on osteomalacia in the cattle of Corrientes. Henry, T.; The behaviour of different species of *Vicia* at La Estanzuela. Horovitz, S., and Marchioni, A. H.; Inheritance of resistance to *Schistocerca paranensis* Burm. in "bitter" maize. Jauch, Clotilde; Disease of *Pisum* in Argentina. Kohler, P.; Pests of stored grain and their control. Lieberman, J.; On some indigenous species of Acrididae injurious to the stock-raising industry of Argentina. Parodi, L. R.; The structure of the spikelets in *Oryza sativa*. Parodi, L. R., and Valencia, J. I.; Study of the types of the species of the genus *Trisetum* (Aveneae). Ringuet, E. J.; Ecological and chemical study of an indigenous forage plant, *Alchemilla pinnata* (family Rosaceae). Santini, B.; Co-operative trials in the Province of Santa Fé. Spangenberg, G. E., Nores, G.; Montedónico, L. A., and Fynn, C. A.; The productivity and quality of natural pastures in relation to soil and climate. Tomasello, J. F.; The locust and new methods of control. Valencia, J. I.; Critical species of *Trisetum* which should pass to the genus *Deschampsia*.

Subjects to which various Congress members drew attention as matters requiring action include the following: Reclamation of marshes, dunes, and eroded lands (A. R. Moreno). Collaboration

with neighbouring countries for the patrolling of forests by aeroplanes and the taking of other measures (defence pickets) for the prevention of forest fires (A. R. Moreno). The utilization and testing of improved agricultural machinery (A. R. Moreno). Determination of the ecological limits within which the growing of any given crop is economic (M. Conti and A. E. Foglia). The economic interpretation of the results of agricultural research (J. B. Pelayo). Inter-American collaboration in agricultural research (R. Sánchez, on behalf of the Venezuelan students of the Faculty of Agronomy, La Plata).

SECOND ARGENTINE CONGRESS ON AGRONOMY

The Second Congress was held at Córdoba in April, 1943, and at its opening the Argentine Under-Secretary for Agriculture, Señor C. A. Erro, made an impressive speech on the urgency of introducing a more diversified form of agriculture into Argentina. (Erro, 1943.) An address on the same subject was delivered by Tenenbaum. (See p. 215.)

FOURTH CONGRESS OF AGRICULTURISTS, CHILE

This was held at La Serena in 1943. Resolutions were passed which expressed "the immediate and permanent aspirations of the agriculturists of Chile" and included the following: "To increase the area devoted to grazing in the stock-raising zones of the south by reclaiming lands at present uncultivated. To carry out a plan to level seasonal differences in the supply of feeding stuffs and consequent seasonal shortages in the meat supply, by means of hay-making, ensilage, and the use of industrial by-products and concentrates. To increase the production of herbage and forage plant seeds and the importation, adaptation and reproduction of different varieties of seed to improve the quality of the Chilean pastures, and to sow these seeds together with cereals, all with the aid of the State and private experiment stations." (*El Campesino, Santiago de Chile*. 1943.)

FIRST NATIONAL CONGRESS ON RURAL SETTLEMENT, URUGUAY

In Uruguay the First National Congress on Rural Settlement, held in 1945, was attended by over four hundred persons. Eight Sections studied legal, social, co-operative and other aspects of rural settlement, Section C being devoted to the consideration of natural factors in relation to farming generally and to the cattle industry. Resolutions were passed recommending legislation and public action in connexion with the intensification of agricultural research in general and in particular increased studies of fertilizers and their application, the endowment of a laboratory for entomology and immunology at the Estanzuela Research Institute and the provision of resources for the regeneration of eroded land; the early reorganization of the Meteorological Service of Uruguay; the establishment of an Institute of Soils and Fertilizers under the Ministry of Animal Husbandry and Agriculture; and measures for co-ordination and planning. (*Rev. Asoc. Ing. agron. Montevideo*, 1945.)

Research up to the present

In discussing research, it is desired to deal in the main with the development and reorganization which are now under way in so many parts of the continent. Organization up to the present, however, in so far as it affects grassland investigations, may perhaps be summarized first.

With one or two exceptions, agricultural research in Latin America has been inaugurated, financed, and generally controlled by the authorities, national or provincial, of the countries concerned.

NON-GOVERNMENT STATIONS

The following are some of the exceptional cases, all having a certain bearing on grassland studies. In Chile the National Society of Agriculture, a vigorous and progressive body which from

1838 onwards has done much to promote agricultural advance in that country, created in 1920 a Biological Institute to which an Experiment Station was soon attached. (Vergara, 1938. Vol. 1. pp. 219-24.) Important plant breeding and seed production work has been carried out by the Experiment Station. Much of this work concerns the famous Peruvian lucernes, and accounts of the Station's reports have been given from time to time in *Herbage Reviews*. (*Herb. Rev.* 1935, 1936, 1940.)

In Argentina a seed-breeding station named the "Chacra Experimental de La Previsión" (or "Foresight Farm"), situated in the southern part of the Province of Buenos Aires, has been successfully operated by a Farmers' Co-operative Society up to 1942, but in that year was transferred to the authority of the Provincial Government of Buenos Aires in consequence of legislation restricting the activities of co-operative societies to insurance business. The Station is concerned to a large extent with the growing of cereals, among which, however, pasture cereals (oats and barley) are included. In addition *Phalaris minor* has been tested as a winter forage plant; and biological studies have been made of *Toxoptera graminum*, a pest of forage cereals and the cause of serious loss to the oat pastures of the province in recent years. (Chacra Experimental de La Previsión, 1942.)

In Uruguay, a country in which the importance of agricultural research has been very generally and effectively recognized, there exists, in addition to the Government Stations, a scientific department of a Co-operative Dairying Society named "Conaprole" (from the words Cooperativa Nacional de Productores de Leche), which does a certain amount of scientific research on subjects affecting the dairying industry. Some interesting ecological studies of grassland have also been made on a private estate (Palleros) in the north-eastern part of Uruguay, and recently a new private Experiment Station has started a study of pasture grasses at Monzon-Heber.

OFFICIAL PROVISION FOR RESEARCH

Official provision for agricultural research differs greatly in the different Latin American countries. The number of research institutes and experiment stations is probably greatest in Brazil, and of these a fairly large number deal with forage and to a certain extent with grassland problems. In Chile, on the other hand, only one official station is in existence, at which also research on plant genetics and seed breeding work takes place. The two Chilean stations, that of the Ministry and that of the National Society of Agriculture, are both situated in the same, the central region. Matthei has pointed out that at least five research stations should be at work in Chile, one for each of the principal climatically differentiated zones and in close proximity to the agricultural capitals of those regions, namely, La Serena, Santiago, Chillán, Temuco, and Osorno. (Matthei, 1939.) The Chilean climatic regional problem is now being partially solved, however, by the conducting of trials under the aegis of the two stations in a number of different places ranging from Ovalle in the north (30° 33' S.) to Llanquihue in the south (41° 15' S.). That the actual number of stations operating is not an absolute index of a country's research level is evidenced by the vigorous work now in progress in Chile. (See pp. 71-2.) (Elgueta, 1943.)

ARGENTINA

Thirty-five Agricultural Experiment Stations work under the Ministry of Agriculture. In the Ministry's Yearbook for 1941 seven are listed, situated in different parts of the country, dealing with special subjects, and working under the Ministry's Division for Experiment Stations. In addition to these the Ministry also disposes of other stations working under the Division for Grain Production and the Division for Tobacco Growing. Of interest for herbage and forage studies are the Station of Colonia Yerúa in the province of Entre Ríos, where forage crops are studied, and that of Cañadón León, Santa Cruz, Patagonia. This station, situated at latitude 48° 40' S.

and longitude 70° west of Greenwich, is of recent foundation, approximately 1939. The climate is characterized by low rainfall (150 to 200 mm. annually) and by very low temperature during the winter season (as low as -25° C.), and the land by stony soil covered with sparse xerophytic vegetation. The region is subject to frequent and extremely violent winds. Experiments comprise the acclimatization of as wide a collection as possible of grasses and forage plants (Leguminosae and other families) for cultivation under both dry conditions and irrigation. The Station disposes of 2,000 hectares of land. Seed samples from regions having similar geographical situation and climatic and soil conditions are welcomed by the Argentine Ministry of Agriculture at Buenos Aires for the use of this station. No reports have as yet been received from these two stations. The Loreto Station in the tropical, forested province of Misiones, though concerned primarily with the growing of maté, has made some interesting studies of climate, erosion and soil conservation and of grassland in relation to the foregoing. (*Almanaque Min. Agric. Argent.*, 1941. *Herb. Rev.*, 1939. Gruener, 1941.)

METEOROLOGICAL RESEARCH IN ARGENTINA

The work of the Ministry of Agriculture's Directorate of Meteorology has a direct bearing upon all agricultural research in the country. An important recent article by Knoche has given an exposition of the author's simplified climatological classification, in which the following scale of temperature is used: 0=cold; 1=subtemperate; 2=temperate; 3=hot; 4=torrid. The scale of humidity is expressed in small letters, as follows: a=very dry; b=dry; c=humid dry; d=humid; e=very humid. The symbols 0 and 3 are again divided as follows: 0I=glacial; 0II=moderately cold; 3I=moderately hot; 3II=intensely hot. The possible combinations of these symbols number 24. For mapping the following colours are proposed for the thermic zones: 0, white; 1, violet; 2, brown; 3, orange; 4, crimson. Certain diagrammatic symbols are proposed for the scale of humidity. (Knoche, 1943.)

PROVINCIAL STATIONS IN ARGENTINA

In addition to the Ministry's Stations there exist provincial Agricultural Experiment Stations. Of these the Station serving the province of Tucumán has done a great deal of work on the trial and adaptation of herbage and forage plants for conditions in the province. It is impossible to summarize here the very full and interesting reports published by this Station, and reference is made to summaries that have already been published elsewhere. (*Herb. Rev.*, 1935-1940. *Herb. Abstr.*, 1941-1944.)

The Santa Fé Agricultural Research Institute has been conducting co-operative trials—many of them concerned with forage plants—from 1938 onwards in localities distributed throughout the whole of the province, with the collaboration of its branch stations, of other research and experiment stations (Rafaela, Pergamino, Santa Catalina), and of numerous farmers, ranchers and seedsmen. (Santini, 1941.)

An important part in Argentine research is played by the Faculties of Agronomy of the Universities of Buenos Aires and La Plata, by the National Museum at La Plata, by the Instituto Fitotécnico de Santa Catalina at Llavallol, F.C.S. (near Buenos Aires), by the Darwinian Institute at Buenos Aires and the Miguel Lillo Institute of the University of Tucumán. The two last-named Institutes, which publish their own periodicals, are concerned mainly with botanical research. The statutes governing the research of the various departments (called institutes) working under the Faculty of Agronomy at Buenos Aires were published in 1938. Work scheduled included genetical and cytological studies of *Zea mays* and breeding for an early form of the bitter maize that is resistant to locust attack; genetical and cytological analysis of the inheritance of sex and other characters in some species of the genus *Poa*; and the collection of material for the

breeding of *Medicago sativa*. Chemical studies included the determination of vitamin A in different varieties of maize and of vitamin C in other forage crop plants; the chemical study of various wild and cultivated plants used for fodder; soil studies and surveys. (Buenos Aires, Universidad. 1938.) Another account of the Faculty of Agronomy's work was published by Marotta in 1944.

BRAZIL

Brazil has a sound tradition in regard to agricultural research. As in Argentina, there are agricultural experiment stations working directly under the Ministry of Agriculture and others, provincial stations, which are under the management of the respective states. The total number of these official stations is not known, but it appears to be very large. A former Ambassador of Colombia to Brazil, addressing the Colombian Society of Agriculturists in 1943 on the development of agriculture in Brazil, speaks of the maintenance of "innumerable experiment fields and farms". Up to quite recently the Government's policy was to create experiment stations and institutes, each dealing with a single crop or commodity such as coffee, wheat, bananas, etc., and directly responsible to the Presidency of the Republic. But the system has not worked well in a country so vast and of such varied conditions as Brazil. The specialist stations became too numerous, they were isolated and scattered, the staffing and equipment problems became difficult, there was a lack of inter-communication, the resultant situation was costly and the public remained uninterested. Reorganization for the co-ordination of research in Brazil is now in progress and promises to be very successful. (Lozano, 1943. Brazil, Min. Agric., 1939, 1940. Camargo, 1941.)

Up to the present the various divisions of the Ministry of Agriculture have had their own experiment stations and this arrangement continues in some respects. The Division for Plant Production, for example, disposes of eight experiment stations, forty-three seed production fields, and eighty-nine areas in which co-operative work is carried out. For the carrying out of its work the country is divided into 138 agricultural zones. (*Bol. Min. Agric. Brazil*, 1943.)

The station specializing in grassland husbandry is the agrostological Station of the National Department of Animal Production, situated at Deodoro, State of Rio de Janeiro. Many of the specialist stations have interested themselves in green manure and cover crops, mostly leguminous. Work done in 1939 at nineteen of the Ministry's stations has been summarized in a recent publication in so far as herbage and forage plants are concerned. (*Herb. Abstr.*, 1942d.)

Since it is impossible to refer to all the Brazilian official experiment stations which have done work of interest for grassland research, the mention of one or two typical stations will not be invidious. In the State of São Paulo, the State Department of Animal Industry maintains four agrostological experiment fields in which collections of herbage and forage plants are under observation, and in the laboratories of the Department itself the nutritional aspect of the forage problem is being studied. (Corrêa, 1936.) In the State of Pernambuco the Animal Production Service was reorganized in 1936 and an experiment station for the testing of herbage and forage plants was established at Rio Branco. A herbarium was being formed at that date, and the subjects of haymaking, the growing of hay plants, and cultural methods in the production of spineless succulents (*Opuntia* spp.), of importance in the arid regions of Pernambuco, were receiving special attention. (Farias, 1936.) The Pindamonhangaba Animal Production Experiment Station in the State of São Paulo takes a lively interest in the pasture question and has published an account of its method of pasture renovation. (See p. 220.) (Salgado, 1939.) The Campinas Institute of Agronomy, also of the State of São Paulo, has nine experiment stations under its control and a scientific staff of twenty-one. The work of the Institute covers many fields, including some study of forage crops, maize and lucerne growing and the like; but perhaps its most striking activity is the study and mapping of the State's soils. (Campinas, Instituto Agronomico, 1935. Lozano, 1943.) Agrostological work under the supervision of the Brazilian Federal Institute of Animal Biology in 1936 included trials of varieties of *Melinis minutiflora* and the reproduction of the most cold-resistant, capable of growing at 1,000 m.; a special study of *Desmodium discolor* and the observation of other *Desmodium* species. The Agrostological Department of the Ministry of Agriculture having insufficient space at its disposal, it was hoped to conduct similar trials in the various Brazilian states.

(*Bol. Min. Agric., Brazil*, 1937.)

Under the Brazilian official research stations should be classed the various Universities and agricultural colleges, at many of which agricultural, including grassland problems are studied.

URUGUAY

Official provision for research in Uruguay is vested in the Faculty of Agronomy of the University of Montevideo, where work was begun in 1907; in the National Directorate of Agronomy at Montevideo; in three Agricultural Experiment Stations situated at Salto, Paysandú and Cerro Largo respectively; and in the Institute of La Estanzuela in the Department of Colonia, founded in 1912. From the University Faculty of Agronomy and from the Institute at La Estanzuela a great deal of information on research has come, and with the creation in 1932 of a special Department at La Estanzuela for the study of forage and industrial plants an impetus was given to grassland investigations. La Estanzuela covers an area of 1,118 hectares and employs a total staff (scientists, administrative, technical and labourers) of approximately ninety. In addition to the Forage Plants Department, there are four more departments dealing respectively with cereals and flax, phytopathology, milling and panification, maize and biology in general. The Institute also operates the official Seed Distribution Service. From 1912 to 1941 it has issued 326 articles and other publications, and the appearance of a well-printed and illustrated journal from 1935 onwards has furnished a valuable source of information on Uruguayan work. With recent developments, the work of the University Faculty of Agronomy and of La Estanzuela has become more closely co-ordinated.

In presenting a bibliography of work on grassland and forage crop investigations, dating from 1776 to 1940, Boerger remarks that the list, which comprises 325 references, is in itself an eloquent proof of the seriousness with which Uruguayan workers have approached their task. (Boerger, 1935, 1937*b*, 1940, 1943. *Herb. Rev.*, 1938.)

OTHER COUNTRIES

Provision for research in Chile has been described already. That in other countries will be referred to in considering recent developments.

Research, recent development

It is convenient to look first at the three great eastern republics in which the animal industry is so important, namely, Argentina, Brazil, and Uruguay.

It is difficult to say when the progressive spirit in regard to research that is now so apparent in these countries was first awakened. So far as grassland research is concerned, it is possible that the great expansion of animal exports in the early part of the twentieth century and the subsequent decline in the twenties and thirties have something to do with it.

DEVELOPMENT OF RESEARCH IN BRAZIL

In Brazil, the whole of the twentieth century, according to Lozano, has been distinguished by progress and by a great increase in agricultural production of various kinds, an increase largely due to the far-sighted action and support of the public authorities. (Lozano, 1943.) Continuous reorganization with a view to greater efficiency and constant expansion are evident everywhere. "Something new is stirring in Brazilian agriculture" wrote Camargo in 1941, when describing the new Northern Institute of Agronomy at Belém. (Camargo, 1941.) In 1939 the Minister for Agriculture, Dr. Fernando Costa, described in the Ministry's Report the reorganization of his Department, and this included the creation of a National Centre of Agronomical Instruction and Research to contain the already existing National School of Agronomy and Institute of Agricultural Chemistry together with newly created Institutes of Ecology and of Agricultural

Experimentation respectively. The last-named Institute is designed to co-ordinate the activities of the Ministry's experiment stations and sub-stations. The Centre is now actually in operation in the State of Rio de Janeiro ; the Ministry's 1939 Report gives views of its magnificent buildings and lay-out. With the centralization of the three Institutes and the National School of Agronomy a high degree of co-ordination and efficiency is to be expected. Engineer G. J. Fischer, Sub-Director of the Institute of La Estanzuela, Uruguay, was seconded to the new Centre in 1939 in an advisory capacity and remained for a period of two and a half years. Some of his impressions were published in 1943.

The new Brazilian Institute of Agricultural Experimentation, created in 1938, has already justified its existence. It has divided the country into economic regions. Each of these regions is to be served by an Institute of Agronomy which, in collaboration with the central Institute, will supervise the activities of a network of experiment stations, already in existence or to be created, and strategically situated in the respective regions. The overlapping and fragmentation of effort which in the past have sometimes characterized the work of the numerous specialist stations are thus to be eliminated and undue specialization is to be avoided. The first of five such Institutes is already in existence at Belém in the State of Pará. It is named the Northern Institute of Agronomy and has a vast area under its supervision, namely, the States of Amazonas, Pará and Maranhão, the northern part of the States of Mato Grosso and Goyaz, and the Acre Territory. It disposes of an area of 3,185 hectares and is housed in specially constructed, well laid out premises (illustrated in the Ministry's 1939 Report). The next Institute to be established will be that serving the North-East, the region which includes Brazil's problem zone of aridity. It will probably be located in the State of Pernambuco.

The third of the regional Institutes will be the Southern Institute of Agronomy, situated at Pelotas in Rio Grande do Sul. Dr. Rouget Perez has just been appointed Director of this Institute, which will supervise all research in the south of Brazil, a region so important for grassland. (Boerger, 1945.)

In the meantime the Institute of Agricultural Experimentation has some twenty-nine experiment stations, seed stations and laboratories under its control. (Brazil, Min. Agric., 1939, 1940. Camargo, 1941. Fischer, 1943. Boerger, 1945.)

Other recent and important creations are two Experiment Stations for Animal Husbandry, one at Bagé in the State of Rio Grande do Sul, where the improvement of the valuable southern grazings is to be taken in hand, and the other at Uberaba in the State of São Paulo for the study of animal nutrition in the central mining regions. (Brazil, Min. Agric., 1940.)

METEOROLOGICAL RESEARCH IN BRAZIL

A formidable obstacle to any long-term planning of agriculture in South America is the (with some exceptions) almost invariable lack of any adequate information on the soils and on rainfall and other climatic factors. This has been realized in the Brazilian measures for reorganization, and the new Institute of Ecology has also been planning on a wide basis, envisaging the establishment of a network of ecological observation posts for the study of the climates and soils of Brazil in their relation to plant production. For the purpose eight main climatic regions are distinguished, namely, Amazonia (super-humid, hot, of immense size) ; Cocaís (intermediate between Amazonia and north-eastern Brazil, having extensive palm woods) ; the north-eastern region, semi-arid, hot ; the maritime belt ; the eastern, semi-humid elevated plains ; the central, semi-humid continental region ; the semi-humid elevated plains of the south, a typically temperate zone ; and the semi-humid southern plain less than 200 metres in altitude. Certain towns are proposed as centres from which the Institute's observations will be made. (*Bol. Min. Agric. Brazil, 1942a.*)

DEVELOPMENT OF RESEARCH IN MINAS GERAIS, BRAZIL

In the State of Minas Gerais a comprehensive and clearly outlined scheme for the study and improvement of the regional grasslands was drawn up by the Department of Agrostology of the State's Inspectorate of Animal Production in 1934. The programme is a model of its kind and has particularly interesting sections on chemical and biochemical research and on pasture management. "If the percentage of losses incurred by the farmers of Minas Gerais through irrational pasture management were known, even approximately, more interest and attention would be devoted to the subject and the establishment of rational grazing standards would be made easy." It is hoped that it has been possible to carry out some part at least of this plan. (Joviano and Santiago, 1934. *Herb. Rev.*, 1934.)

DEVELOPMENT OF RESEARCH IN URUGUAY

It has been mentioned that research in Uruguay has been steady and continuous. It received, however, a great impetus in 1935 with the creation by Government decree of a National Commission for the Study of the Forage Problem. On this occasion the Minister for Agriculture drew attention to the value of the work already done and stressed the need of co-ordination. The Commission was composed of the Director of the Estanzuela Institute (as Chairman), of members of staff of the University's Faculty of Agronomy, and of Government agricultural officials. A plan of work was published in 1936 wherein especial emphasis was laid upon the co-ordinated study of the soils and vegetation of every part of the country. Reports on the first two years' work, published in 1938 and 1939, showed great progress to have been made with this survey and with the Commission's other projects, and in 1941 a full report on the survey was published. Reference has already been made to this work (see pp. 36-50). The Commission's activities continue and are likely to have far-reaching results upon the pastoral industry not only of Uruguay, but of Latin America generally. (*Herb. Rev.*, 1935, 1936, 1940. G. E. Spangenberg, Nores, Montedónico and Fynn, 1941.)

DEVELOPMENT OF RESEARCH IN ARGENTINA

It is possible that the very ease with which prosperity is achieved in Argentina has caused interest in agricultural research, while always intense in some quarters, to be somewhat less general and less generously supported in that country. There is, however, much to show that at the present time Argentina also is keenly alive to the urgency of progress in this direction. Special prominence was given to the subject at the First Argentine Congress of Agronomy held at Buenos Aires in 1941. An important feature of this Congress was Professor Lorenzo R. Parodi's address on the organization of agricultural research in the Republic, in which a plea was made for a great extension of research facilities and advisory centres. It was asserted that in many places the agricultural technique of the seventeenth century is still employed. Attention was drawn to the anomaly of a stock-raising country such as Argentina being without an institute for the study of herbage and forage problems, and to the consequent lack of guidance and information for graziers. Aspects of organization discussed included the relations of the Ministry of Agriculture to the research and educational centres, the appointment of personnel, the planning of research, the nature of the research and experiment stations, regional advisers and advisory centres, and agricultural education. (Parodi, 1941f.)

The recommendations of a special committee on the organization of agricultural research, appointed by the Argentine Society of Agronomy, are included in the Congress Report. The Congress resolved that legislation for the co-ordination and promotion of agricultural research was a matter of urgency, and that a Commission for the immediate formulation of a law should be nominated, the draft to be considered by an assembly organized by the Argentine Society of Agronomy.

(Incidentally, another resolution of the Congress, following on an exposition of grassland analysis by Burkart, provided that "by preference, for the census or botanical analysis of the natural grasslands of the Argentine Republic, Levy and Madden's point method be used, a method which has been shown to be of sufficient exactitude for expressing the quantitative relations between the components of grassland and has the advantage of being rapid.") (Burkart, 1941c.)

At the opening of the Second Argentine Congress on Agronomy in 1943, again, the Under-Secretary for Agriculture made a plea for the establishment of research and experimental work on a scale more in keeping with the actual resources of the Argentine Republic. (Erro, 1943.)

Progressive action recently taken by the Argentine Republic has been the creation in 1944 of a Division of Exploration and Plant Introduction under the Ministry of Agriculture. Its functions are the obtaining, by means of exploration and exchange, of living plant material; the conservation of living cultures of such material; its distribution and exchange; and the periodic publication of inventories, reports, and scientific information in connexion therewith. The Division has a scientific staff of five under the directorship of Engineer E. C. Clos. Land is available at Castelar in the province of Buenos Aires and at Yeruá in the province of Entre Ríos, and it is possible that another area may be obtained in the Territory of Misiones. Tours for the collection of material have already been made in Formosa and Misiones and in the central and north-western parts of the province of San Luis. (*Noticioso, B. Aires, 1944a. Rev. Argent. Agron., 1945.*)

The active work of the Argentine Soil Conservation Service, the Chief of which has studied in the United States, has already been mentioned (pp. 183, 186).

In connexion with Argentine research and planning, attention should be drawn to an article by Ortiz which stresses the importance of climatological study as the basis of crop selection and planning. (Ortiz, 1942.)

DEVELOPMENT OF RESEARCH IN CHILE

Turning now to some of the other Latin American countries, it will be seen that almost everywhere an increased recognition of the importance of agricultural research—at the lowest, of agricultural organization—is evident. In Chile this recognition is a direct corollary of the great industrial expansion of that country, which has provoked something like an agricultural crisis. The vigorous action that is now being taken to meet this crisis has already been described (see pp. 71-2). It is sufficient to recall here that improvement of the natural and sown grasslands plays an important part, and for this purpose a comprehensive research programme has been entered upon by the Genetics Department of the National Department of Agriculture and the Experiment Station of the National Society of Agriculture, working in collaboration. Study of indigenous and exotic species of herbage plants is being made in different localities over an area extending from 30° 33' S. to 41° 15' S., and promising species are being reproduced and distributed. At the same time selection is being made of wild and cultivated Chilean plants, especially in the central zone, and studies of chemical composition, palatability and yield are in progress. Farmers are invited to co-operate by sending reports of results obtained from their own experience. (Buchner, 1942a. Elgueta, 1943.)

DEVELOPMENT OF RESEARCH IN VENEZUELA

Venezuela is another country in which vigorous action is now being taken to improve the basis of the stock-raising industry through research and exploration. The Ministry of Agriculture has conferred with the Government of the United States on the question of furthering agricultural production in Venezuela. As a result a Food Production Mission under the leadership of Mr. G. L. Crawford is surveying the country's natural resources and studying the best measures for immediate adoption. The Commission met the National Association of Graziers and informed them that

one of the foremost tasks of the Mission is to study the best means of conserving the natural herbage of the country, for the purpose of relieving the intense shortage of cattle feed generally felt at the height of summer. The Association expressed a cordial desire to collaborate in this work. The State of Aragua has been visited, with a view to the improvement of its grasslands and the initiation of ensilage, and also the State of Cojedes, one of the most important stock-raising zones in Venezuela. (*Agricultor Venez.*, 1943.)

A Soil Conservation Service has recently been established (Klugh and Rugeles, 1944), and the appointment of an official agrostologist to the Ministry of Agriculture is another advance made by Venezuela. (Chase, 1944.)

DEVELOPMENT OF RESEARCH IN PERU

Peru has thirty official agricultural experiment stations and substations dispersed fairly evenly throughout the country. Of these, the stock-breeding farm at Chuquibambilla in the Department of Puno, situated at an altitude of 13,000 feet (approximately 4,000 metres) is doing valuable work not only in regard to animal breeding but also in regard to grassland management. (Stordy, 1938.) A recent publication by Barducci of the Lima Agricultural Experiment Station shows, however, that there is a felt need for an expansion and at the same time a co-ordination of agricultural research in Peru, especially in connexion with the provision of improved seed. At present only four of the official stations, all situated in the northern part of Peru, are engaged in plant breeding, and herbage and forage plants are as yet untreated. Barducci plans a network of sixteen breeding stations to be located at various of the existing stations so as to serve the different climatic, topographic and agricultural zones. Herbage and forage plants, under this scheme, would be included in the material. There is further planned a network of seed reproduction stations for the distribution of improved seed to the farmers of Peru. (Barducci, 1944.)

DEVELOPMENT OF RESEARCH IN COLOMBIA

In Colombia herbage and forage plants are studied and acclimatized at the Experiment Station of La Picota, situated in the high lands near Bogotá. (Abadia, 1943.)

Disquieting circumstances in the national agricultural situation are revealed in a recent publication of the Director of the Department of Agriculture, Dr. Carlos Madrid, who asserts that the output of agricultural products in Colombia is, in general and in every branch of the industry, far below the country's actual requirements. Previous plans for improvement have been wrecked for lack of adequate financial support on the part of the Government. It is now imperative—in order to balance and support the increasing industries of Colombia and to cover the country's food requirements—not only that money should be voted for the carrying out of a Five-Year Plan of agricultural improvement, but also that certain products should receive protection, that agricultural credits should be established, that prices should be regulated and harvests properly distributed. An important part of the Five-Year Plan outlined by Madrid is the maintenance of agricultural education and of agricultural research and experimentation through the Institute of Biology and ten agricultural experiment stations situated in the various climatic regions of the country. Another point of interest to the Colombian stock raiser is the improvement of means of communication, for according to Wylie and Hopkins one of the chief problems of the Colombian llanos—a great potential stock-raising area—is that of transport. (Madrid, 1945. Wylie, 1942. Hopkins, 1946.) Culbertson asserts that progress is now being made in this direction. (Culbertson, 1946.)

RESEARCH IN ECUADOR

Little is known on agricultural research in Ecuador, but that the need for a general development and expansion of agriculture is felt in that country is evident from the address on the

"agricultural potentialities of Ecuador in the service of the American continent" that was presented by the Director General of Agriculture and Animal Husbandry to the Eighth American Scientific Congress in 1940. (Ordeñana, 1942a. *Herb. Abstr.*, 1943.) The Ministry of Agriculture has recently published a treatise on grasses for the assistance of the stock raiser in Ecuador (Katz, 1943), and it is known that the Agricultural Experiment Station at Ibarra is studying, among other subjects, the suitability of many different herbage plants for use in the mountain province of Imbabura and is shortly to acquire high-grade livestock with a view to the improvement of the existing provincial stock. (Burbano and Ruiz, 1943.) Solís has published an account of the climates of Ecuador. (Solís, 1944.)

RESEARCH AND DEVELOPMENT IN BOLIVIA

In Bolivia there is an Agricultural Research Station at Chulumani, near La Paz, but it is not known if any work on grassland problems takes place. There has recently been an awakening in that country to the need for agricultural reorganization. "In further delineation of its policy of making Bolivia agriculturally self-sufficient, the Bolivian Government in recent months has made a number of significant moves. These include: (1) The formation of the Bolivian Development Corporation, the purpose of which is, in part, to promote Bolivian agricultural production; (2) the re-establishment of a Ministry of Agriculture; (3) the decision to take a national agricultural and livestock census, as a means of determining the nature and extent of the country's agricultural resources; (4) the creation of the Agricultural Bank of Bolivia; and (5) the promotion of certain irrigation projects." (Nolan, 1943.) A useful study by Prada Estrada of the very diverse climates of the country has now been published by the Ministry of Agriculture. (Prada Estrada, 1946.)

RESEARCH IN CENTRAL AMERICA

In Central America also the spirit of progress is evident at present. In Guatemala renewed interest in all branches of agriculture, including that of stock raising, is reflected in the pages of the Ministry's journal.

COSTA RICA

It is in the Republic of Costa Rica, probably, that agricultural research is most highly developed in Central America. Reference has been made already to the study of herbage and forage problems made at the National Centre of Agriculture situated in the central plateau. (See pp. 89 and 129.) (Orozco, 1939.) In addition to this research centre there are four newly established experiment stations. These are located respectively at Birrisito at an altitude of 1,500 m. in a temperate climate subject to Atlantic influence; at Palmares, altitude 900 m., climate, fresh warmth to intense heat; at Ojo de Agua in the eastern part of the central plateau, altitude 950 m., climate temperate rather than hot; and at Porvenir. The Birrisito and Porvenir Stations are both engaged in grassland studies. (Esquivel, 1941.)

PLANT BREEDING RESEARCH

Since the foregoing account was written, a full description of Latin American research in the fields of plant breeding, genetics and cytology has been published by Krug. The leading countries in these sciences, writes Krug, are Brazil, Argentina, and Uruguay, in all of which outstanding work has been done, but there are still an enormous number of problems awaiting attack, most of the work so far completed being of a preliminary nature. (Krug, 1945.)

INTER-AMERICAN RESEARCH

A recent development of much interest is the inauguration in 1943 of the Inter-American Institute of Agricultural Sciences at Turrialba, a town in the interior of Costa Rica, fifty miles from

San José, the capital, and seventy-five miles from Puerto Limón, the principal port. The Institute is conceived as a combined school of agriculture and an agricultural research centre, the facilities of which will be used by all of the American republics. It is not so much an academic organisation, however, as an institute of applied research. Its objectives include the provision of a place for research on tropical agriculture, the furnishing of facilities for training scientific personnel grounded in tropical agricultural problems, service as a centre for co-operative research, and the strengthening of cultural relations among the American republics. The officials are drawn from the United States and from Latin America, and plans contemplate the utilization of research facilities offered by the governments of several Latin American republics besides that of Costa Rica, namely, Argentina, Bolivia, Brazil, Colombia, Mexico, Peru, and Cuba. (*Agric. Americas*, 1942b, 1943.)

In El Salvador an agricultural experiment station operated jointly by the United States and various other American republics has been established, and projects already initiated include the plant analysis of forage crops. Special attention is to be given to feeding trials of domestic forage plants, some of which have a very high protein content. Eventually substations will be established in different parts of El Salvador for the testing of new methods and new plants under various conditions. (Barrientos, 1943.) There are similar joint stations in some of the other American republics. A general account of this type of co-operative work has been given by L. W. Witt (1945).

It is hoped that the foregoing study, while by no means exhaustive, will serve to give some impression of the grassland problems of Latin America and of the steps that are being taken for their solution.

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 ABERYSTWYTH, Imperial Bureau of Pastures and Forage Crops, 78, 188, 224
 ACEVEDO, Rebeca, 226
 ACUÑA, J., 135
 AGEZ, J. Calderón, 62
 AGRICULTOR VENEZOLANO (EL), 238
 AGRICULTURE IN THE AMERICAS, 201, 216, 218, 240
 AGUILAR G., J. I., 166, 168, 169, 170, 171, 173, 174, 175, 177
 ALARCÓN, V. M. V., 194, 228
 ALBÉNIZ de la CERRADA, D., 117
 ALBERTS, H. W., 78, 165, 166, 167, 169, 174
 ALENCAR, R. de, 104, 177
 ALMANAQUE del Ministério de Agricultura, 202, 204, 232
 ALMEIDA, A. O. de, 226
 ALVES, L., 221
 AMSHOFF, G. Jane H., 225
 ANAIS da PRIMEIRA REUNIÃO Sul-Americana de Botânica, 228
 ANDRÉS, J. M., 226
 APOLINAR MARÍA (Hermano), 226
 ARAGONE, L., 242, 266
 ARAUJO, A. A. de, *see* Avila de Araujo
 ARECHAVALA, J., 225
 ARENA, A., 33, 106, 107, 110, 137, 183, 185, 186, 191, 217, 229
 ARGENTINA, Dirección de Agricultura, Laboratorio de Ingeniería Rural, 222
 ARGENTINA, Dirección de Ganadería, División de Policía Sanitaria, 180, 203
 ARGÜELLO, A. T., 150, 158, 160, 217, 223
 AROCENA, E. Terra, 191, 213-4
 ARRIVILLAGA, J., Jr., 196
 ASPLUND, E., 226
 ASTURIAS M., G., 145
 ATWOOD, Alice C., 97, 224
 AVILA DE ARAUJO, A., 55, 158, 166, 167, 168, 169, 171, 173, 176
 AYALA, A. C., 155, 158
 AZNAREZ, M., 142
 BABCOCK, 141
 BAEZ, J. R., 56-60, 229
 BALL, J., 93, 95, 96
 BARBOSA, G. L. A., 217
 BARDUCCI, T. B., 78, 238
 BARRIENTOS, L., 240
 BARROS, R., 102, 161, 167, 168, 169, 171, 172, 173, 175, 176, 177, 213
 BAZZI, 137
 BEARD, J. S., 90, 119, 132
 BECKER, H. F., 88, 89, 127, 128, 129
 BEETLE, A. A., 93, 96, 164
 BEHN, K., 167
 BELAUNDE, C. L., 208
 BELLINI, V. T., 147
 BENNETT, H. H., 183, 196, 198
 BENTANCUR, M. O., 149, 182, 191, 207, 229
 BERGALLI, L., 244, 266
 BEWS, J. W., 120
 BEYERLE, R., 226
 BITANCOURT, A. A., 207, 228
 BITTENCOURT, H. V. de C., 188-90
 BLAKE, S. F., 97, 224
 BOERGER, A., 21, 22, 35, 36, 48, 49, 50, 137, 141, 142, 143, 146, 147, 148, 150, 151, 153, 154, 158, 106, 133, 134, 158, 159, 160, 162, 179, 191, 192, 199, 200, 204, 205, 207, 208, 209, 210, 214, 216, 217, 218, 219, 222, 228, 234, 235, 236
 BOLETIM de AGRICULTURA, MINAS GERAIS, 210
 BOLETIM DO MINISTÉRIO DA AGRICULTURA, BRAZIL, 188, 221, 233, 235
 BOLETIN de AGRICULTURA, COLOMBIA, 160, 161
 BOLETIN de LA CHACRA EXPERIMENTAL de "LA PREVISIÓN", 147
 BONE, T., 132
 BONJOUR, A. A., 148, 179, 180, 192, 203, 216
 BORNMUELLER, J., 54, 226
 BOTERO, R. O., 196
 BOUILLENNE, R., 130, 131, 226
 BRAVO H., Helia, 245
 BRAZIL, Diretoria de Estatística da Produção, 158
 BRAZIL, Ministério da Agricultura, 142, 154, 158, 160, 161, 202, 205, 217, 233, 235
 BRAZIL, Serviço de Informação Agrícola, 217
 BREDEMANN, G., 203, 204
 BRETON, R., 207
 BRITO, O. da Silva, 52, 53, 54, 55, 134
 BROTONS, C., 148
 BRUCK, E., 210
 BUCHNER, E., 159, 160, 162, 222, 223, 237
 BUENOS AIRES, Universidad, Facultad de Agronomía y Veterinaria, 233
 BUKASOV, S. M., 113
 BURBANO, J., 239
 BURDENSKEI, D., 204
 BURKART, A., 22, 33, 136, 138, 139, 140, 142, 150, 151, 152, 153, 154, 155, 157, 160, 161, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 181, 182, 202, 206, 210, 221, 222, 224, 225, 229, 237
 BURRET, M., 226
 CABRERA, A. L., 247
 CALDEVILLA, G. M., 192
 CAMARGO, F. C., 233, 234, 235
 CAMPAL, E. F., 247, 266
 CAMPESINO (EL), Santiago de Chile, 222, 223, 230

- CAMPI, Maria Dolores, 207
 CAMPINAS, Instituto Agronómico do Estado, 233
 CANEL, M., 204, 226, 229
 CANELA, P. T., 159
 CANO, A. E., 219
 CARABIA, J. P., 135, 227
 CARBONELL MÁS, A., 221, 222
 CÁRDENAS, M., 133, 227
 CARNEIRO, G. G., 220
 CARRERA, C., 206, 207
 CASTELLANOS, A., 62, 97, 106, 177, 227
 CASTRO G. H., A., 221
 CHACRA EXPERIMENTAL de "LA PREVISIÓN", 231
 CHALTEIN, F., 200
 CHASE, Agnes, 85, 91, 120, 123, 124, 127, 128, 202, 212, 226, 238
 CHEBATAROFF, J., 248
 CHRISTIANS, W. F., 33, 35
 CHRONICA BOTANICA, 118, 120
 CLOS, E. C., 152, 225, 226, 228, 229, 237
 COINER, Mary S., 84, 118
 CORRÊA, M. Pio., 54, 128, 153, 154, 161, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 182, 224
 CORREA, M. R., 159
 CORRÊA, P. de Lima, 115, 233
 COSTA, A., 157, 158, 180
 COSTA, F., 115, 116, 188, 190, 234
 CROSS, W. E., 155, 156, 157, 158, 159, 160, 208, 215
 CROVETTO, R. M., 249
 CUATRECASAS, J., 226
 CUBA, P. A., 190
 CUBA, P., 142
 CUCCIOLI, C. D., 152
 CUFODONTIS, G., 226
 CULBERTSON, R.E., 238

 DAHLBERG, A. C., 89, 90
 DAIREAUX, G., 214
 DANIEL, H., 225
 DANKERT, E. G., 141
 DARKENWALD, G. G., 118, 123, 124, 126, 127, 134, 135
 DAVIES, H., 250
 DAVIES, W., 21, 22, 33, 48, 59, 60, 62, 63, 64, 71, 96, 97, 98, 99, 137, 150, 151, 163, 164, 169, 172, 177, 183, 184, 201, 202, 212, 218
 DEFRAJÁS, R. M., 214
 DEGER, E., 217
 DEGER, E. C., 196, 217
 DELLAZOPPA, J. G., 149, 229
 DEMEL, H. v., 105
 DIELS, L., 226
 DOMINGUES, O., 51, 52, 54, 56, 100, 101, 102, 103, 104, 114, 129, 131, 133, 134, 145, 161, 167, 168, 171, 173, 174, 175, 177

 DOWLING, J. O., 159
 DUCKE, A., 130, 224, 225, 226, 227
 DUGAND, A., 80, 81, 125, 126
 DURAN M., L., 206
 DUSÉN, P., 250, 257
 DUTRA, J., 54

 ECHENIQUE, L., 180, 182
 EICHLER, A. W., 54
 ELGUETA G., M., 70, 71, 72, 150, 155, 159, 160, 178, 194, 231, 237
 ELIAS, R. G., 78
 ERRO, C. A., 214, 230, 237
 ESPINOSA B., M. R., 251
 ESQUIVEL, R. C., 89, 239

 FALBO, F. L. G., 78
 FALZONI, E. A., 213, 218, 219, 220
 FARIAS, R. de, 104, 233
 FAURÉ, G. O., 206
 FERNANDES, J. Sampaio, 181
 FERNANDES E SILVA, R., 164, 168, 169, 170, 172, 173, 176, 177
 FERNANDEZ, C. M., 182
 FERNÁNDEZ, R. F., 179, 203
 FERRI, M. G., 116
 FINA, A. de, 226
 FINA, A. L. de, 152, 226, 229
 FINCH, V. C., 123
 FIORDA, H., 64, 93-5, 95, 98, 99, 183
 FISCHER, G. J., 148, 206, 217, 235
 FOLLETT-SMITH, R. R., 132
 FRANK, Waldo, 16, 20
 FREISE, F. W., 99, 100
 FRENGUELLI, J., 87, 88, 106, 109, 110, 226
 FRIGERIO, R., 185
 FLYNN, C. A., 37, 38-45, 199, 200, 229, 236

 GALINDO, D., 158
 GALLEGOS P., J., 77
 GALLINAL, J. P., Jr., 46
 GARCÉS, C. M., 175
 GARCIA, E. T., 156
 GARMENDIA, L. I., 191
 GARRÓS, S. F., 147
 GEHLSSEN, C. A., 191
 GENTRY, H. S., 165, 169, 170, 171, 173, 174, 176, 177
 GHEORGHIANOV, V., 148
 GIESBRECHT, G., 190, 191
 GIROLA, C. D., 157
 GIUSTI, L., 180, 181
 GLEASON, H. A., 84
 GOETZ, A., 216
 GÓMEZ, E. F. C., 46
 GÓMEZ, M. M., 200, 209

- GONZALEZ, A. de J., 212
 GOOD, R., 252
 GOULART, M. D., 241, 252
 GOYTÍA, A., 204
 GRIOT, M., 205, 206
 GRUENER, G., 183, 187, 188, 210, 232
 GUERÍN, M. E., 192, 193—4, 228
 GUEST, P. L., 227
 GUIÑAZÚ, J. R., 33, 107, 110, 183, 185, 186, 229
 GUNCKEL, H., 225
 GUYOT, R. A., 209
- HAMBLETON, S., 253
 HARDY, F., 17, 56, 95
 HAUMAN, L., 53, 62, 63, 95—6, 206, 226, 227
 HAYWARD, K. J., 150, 205
 HEILBORN, O., 91
 HENRARD, J. T., 226
 HENRY, T., 48, 142, 147, 148, 154, 158, 203, 234
 HERBAGE ABSTRACTS, 101, 188, 192, 193, 227, 232, 233, 239
 HERBAGE REVIEWS, 47, 48, 231, 232, 234, 236
 HERRARTE, M. P., 195
 HERRERA, F. L., 75, 170, 172, 173, 174, 176, 177, 225
 HERTER, G., 254
 HERTER, W., 226
 HERTER, W. G., 206, 226
 HIERONYMUS, J., 165, 212, 213, 226
 HITCHCOCK, A. S., 75, 79, 98, 128, 226
 HODGSON, R. E., 89, 90
 HOEHNE, F. C., 134, 225
 HOESS, J., 140, 141
 HOPKINS, J. A., 238
 HOROVITZ, S., 204, 229
 HOSSEUS, C. C., 213, 227
 HUDSON, W. H., 16, 18, 19, 34, 84, 210
 HULL, W. X., 198
 HUMBOLDT, A. von, 117, 120
- IBARRA, Florinda E., 209
 IELPO, M., 241, 255
 IPPISCH, F., Jr., 255
 ISAZA M., J. M., 155, 156
 ITIÉ, G., 128, 226
 ITO, S., 149, 150, 215
- JAFFUEL, F., 255
 JAMES, Preston E., 9, 17, 20, 21, 22, 32, 35, 51, 55, 63, 70, 72, 74, 75, 80, 83, 84, 88, 89, 91, 92, 100, 103, 106, 110, 111, 113, 117, 118, 122, 123, 124, 125, 129, 131, 133, 134, 135, 201
 JIRKAL H., J., 194
 JOB, Maria M., 255
 JOHNSON, Esther H., 112, 114, 164
- JOHNSTON, I. M., 227
 JONES, C. F., 95, 118, 123, 124, 126, 127, 134, 135
 JOURNAL of the JAMAICA AGRICULTURAL SOCIETY, 202
 JOVIANO, R., 236
 JUKES, 141
- KAERGER, 174
 KATZ, C., 79, 80, 162, 207, 239
 KEELER, I. P., 115, 215—6
 KILLIP, E. P., 84
 KLEIN, V., 195, 196, 217
 KLINKOWSKI, M., 136, 137, 138, 141, 142, 143, 144, 145
 KLUGH, R. H., 156, 198, 238
 KNOCHE, W., 92, 178, 232
 KNUCHEL, H., 74, 92
 KOK, E. A., 115, 136, 153, 223
 KÖPPEN, W., 17, 18
 KRUG, C. A., 239
- LA PORTE, J. J., 209
 LAHITTE, R., 225
 LANKENAU, R. F., 115, 215—6
 LANJOUW, J., 130, 132
 LANUSSE, G. A., 209
 LECUBE, C. L., 159
 LEONARDI, L. A., 46
 LERENA, C. A., 33, 200, 201, 218
 LIEBERMANN, J., 184, 185, 203, 229
 LIEBSCHER, W., 105
 LINDMAN, C. A. M., 53, 54, 226
 LOPEZ, A., 99
 LORENZINI, O. A., 162
 LOZANO y LOZANO, C., 233, 234
 LUCES MORETTI, Zoraida, 120
 LUCES, Zoraida, 84, 85, 91, 122, 225
 LUTZELBURG, P. von, 129, 131, 226
 LUNDELL, C. L., 167, 226
- MACBRIDE, J. F., 75
 MACLOSIE, G., 98
 MCCULLOUGH, W. B., 16, 17, 20, 21
 MACHADO, O., 181
 MADARIAGA, Salvador de, 9
 MADRID, C., 238
 MALME, G. O. A., 54, 225
 MARCHIONATTO, J. B., 137, 204, 205, 207, 229
 MARCHIONI, A. H., 204, 229
 MARCÓ, P. R., 140, 152, 206
 MAROTO, A. S., 90
 MAROTTA, F. P., 233
 MARTIN, R. R., 210
 MARTINEZ, M., 165, 166, 167, 168, 169, 171, 172, 173, 174, 175

- MARTIUS, C. F. P. von (or K. F. P. von), 54, 102, 226
- MARTYN, E. B., 130, 132
- MAS Y GUIDAL, J., 182
- MASCHERONI, E., 78
- MASON, D. I., 214
- MASSAUX, R., 147
- MATTHEI, A., 70, 72, 136, 143, 144, 145, 151, 231
- MEDINA V., H., 178
- MELLO, E. M. Moraes de, 181
- MENDES, C. T., 221, 223
- MENDÍVIL, R. V., 75, 76, 160, 213, 219, 220
- MENEZES SOBRINHO, A., 214
- MILLE, L., 79, 226
- MINNEMAN, P. G., 135
- MINTZER, M. J., 185
- MIRANDA, G. J., 222
- MIRANDA, O. da R., 258
- MONTEDÓNICO, L. A., 37, 38-45, 199, 200, 222, 229, 236
- MONTEIRO, F. P., 218, 219, 223, 226
- MONTEIRO, H., Jr., 258
- MONTICELLI, J. V., 107-9, 110, 226
- MONTORO GUARCH, A., 206, 207
- MORENO, A. R., 198, 229, 230
- MORETTI, O., 186, 187
- MULLER, A. S., 259
- MUÑOZ PIZARRO, C., 155, 226
- MUTINELLI, A., 154, 161, 228
- MYERS, J. G., 117, 118, 119, 120, 124, 132, 165, 211
- NAVARRETE, J. P., 166, 173
- NICORA, Elisa G., 225
- NIEVES, R., 137
- NOLAN, L. C., 239
- NOLL, W., 210, 216
- NORES, J. G., 37, 38-45, 149, 210, 221, 222, 229, 236
- NORONHA, H., 99, 100, 101
- NOTICIOSO, B. Aires, 70, 88, 204, 215, 237
- NYHUS, P. O., 20, 21, 28, 137, 201
- OCCHIONI, P., 181
- OCHOTERENA, L., 111-2, 114, 226, 227
- OPAZO G., R., 70, 71, 72, 73, 88, 143, 144, 145, 150, 151, 152, 153, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 228
- ORDEÑANA, E. M., 78, 79, 194, 195, 239
- ORELLANO, O. B., 175
- OROZCO, J. M., 89, 128, 129, 173, 182, 214, 239
- ORTIZ, A. A., 237
- OSPINA O., G., 201
- OTOYA, F. J., 196
- PARADES, A., 79, 227
- PARODI, L. R., 18, 19, 20, 22-8, 56, 58, 59, 63, 64, 65-9, 86-7, 87, 98, 106, 133, 135, 137, 145, 146, 153, 154, 157, 159, 160, 163, 165, 166, 170, 172, 174, 175, 181, 182, 186, 187, 206, 207, 208, 209, 212, 222, 225, 226, 228, 229, 236
- PASTORE, Ada I., 153, 154, 229
- PATÍÑO, L. R., 113, 196
- PAULSEN, E. F., 183, 226
- PENLAND, C. W. T., 90
- PENNELL, F. W., 227
- PERAK, J. T., 226
- PERALTA, L. R. M., 263
- PÉREZ, H. M., 187
- PÉREZ, R. P., 196-7
- PEREZ-MOREAU, R. A., 97, 106, 227
- PETERY, W. von, 137
- PHYSEY, B. R., 115, 205, 220
- PILGER, R., 226
- PIÑEROS, J., 158
- PINTO, A. V., 241, 264
- PIO CORRÊA, M., *see* Corrêa, M. Pio
- PITTIER, H., 83, 84, 85, 89, 90, 91, 117, 118, 119, 120, 122, 123, 124, 144, 164, 165, 167, 168, 169, 171, 173, 174, 175, 177, 210, 212, 225
- POPENOE, W., 92
- POPOVA, G. M., 264
- PRADA ESTRADA, R., 239
- PULLE, A. A., 132, 226
- QUEVEDO, J. M., 200, 229
- QUEVEDO, M. T. V., 79
- QUINTEROS, M., 191, 213-4
- RACHID, Mercedes, 116
- RADELOFF, H., 203, 204
- RAGONESE, A. E., 139, 140, 141, 206
- RAINIER, P. W., 117
- RAMOS de OTERO, 176
- RATERA, E. L., 180, 181, 207, 209
- RAWITSCHER, F. K., 116, 213, 226
- REICHERT, F., 59, 170, 173, 225, 226
- RENWICK, A. M., 77
- RETE, B. O., 200
- REVEILLEAU, A., 221
- REVISTA AGRÍCOLA, GUATEMALA, 156
- REVISTA ARGENTINA de AGRONOMÍA, 237
- REVISTA de la ASOCIACIÓN de INGENIEROS AGRONOMOS, MONTEVIDEO, 230
- REVISTA de la FACULTAD de AGRONOMÍA, B. Aires, 210
- REVISTA de la FACULTAD de AGRONOMÍA, MONTEVIDEO, 142
- REYES, R. V., 80, 81, 82, 83, 125, 127, 128, 161, 162, 211, 218
- RHOAD, A. O., 213
- RIBEIRO, R., 191, 229

- RICH, J. L., 56
 RIET, E., 199, 203, 212
 RIET, J., 180
 RINGUELET, E. J., 82, 87, 92, 206, 229
 RIVERA, Irene, 207
 RIVEROS, J. E., 217
 ROCHA, F. Alves de, 55
 RODRIGUEZ, L., 204
 ROIG y MESA, J. T., 135
 ROJAS, T., 227
 ROSA-MATO, F., 192
 ROSENBUSCH, F., 181
 ROSENGURTT, B., 46, 165, 166, 167, 169, 170, 171, 172, 173, 174, 175, 176, 177, 182, 224
 ROSENGURTT GURVICH, B., 252, 266
 ROUGET PÉREZ, J., 200, 235
 RUBINO, M., 199, 200
 RUEDA, M. Gómez, 80, 81, 82, 83, 125, 127, 128, 161, 162, 211, 218
 RUFFINELLI, A., 206
 RUGELES, J. A., 156, 198, 238
 RUIZ P., C., 239
- SALAS, J. G., 167, 170
 SALGADO, J. C., 220, 233
 SAMPAIO, A. J. de, 225, 226
 SAMPAIO, B. C. de, 223
 SANDWITH, N. Y., 91, 226
 SANTA CRUZ, A., 182
 SANTIAGO, E. C., Jr., 236
 SANTINI, B., 229, 232
 SANZ, D. L., 180
 SAURA, F., 226
 SCHELOTTO, B., 146, 159
 SCHERY, R. W., 267, 271
 SCHIEL, E., 141, 152
 SCHIMPER, A. F. W., 102, 114, 119
 SCHIUMA, R., 204
 SCHMIDT, F. M., 103
 SCHMIEDER, O., 17, 18, 19
 SCHULTZ, E. F., 157, 208-9, 215
 SECKT, H., 254, 269
 SEIFRIZ, W., 135
 SEMPLE, A. T., 28, 29-31, 60, 61, 67
 SHREVE, F., 111
 SIERRA, H. M., 144, 145, 156
 SILVA, A., 155, 158
 SILVA, M. Rocha e, 181, 182
 SILVA, M. T. da, 221
 SILVA, R. Fernandes e, 104
 SIMPSON, E. N., 113
 SÍVORI, E. M., 226, 229
 SKOTTSBERG, C., 257, 268
 SMITH, A. C., 130, 131, 132, 227
 SMITH, M. G., 114, 128
 SOBRERO, L. R., 223
 SODIRO, L., 79, 226
- SOLÍS, M. A., 227, 239
 SOÑORA, L. U. B., 46
 SORDO, J. A., 136
 SOSA, C. L., 204
 SOUTH AMERICAN HANDBOOK, 89, 133
 SOUZA, A. J. de, 105, 167, 168, 169, 170, 171, 172, 173, 174, 176, 177, 178
 SPAFFORD, W. J., 137
 SPANGENBERG, G. E., 35, 36, 37, 38-45, 46, 48, 49, 142, 191, 199, 203, 212, 219, 236
 SPANGENBERG, J., 148
 SPAGAZZINI, C., 98
 SPRUCE, R., 131
 SQUIBB, R. L., 202
 STANDLEY, P. C., 75, 89
 STEYN, D. G., 178
 STORDY, R., 76, 77, 218, 238
 STORK, H. E., 269
 SUAREZ F., J., 155
 SUESSENGUTH, K., 226
 SVENSON, H. K., 79
 SWALLEN, J. R., 226
- TAGLE, E. C., 32, 33, 110, 149, 201
 TAMAYO, F., 270
 TAPPY, Elizabeth P., 78
 TATE, G. H. H., 84
 TENEMBAUM, J. L., 214, 215, 230
 TEODORO, J., 270
 THELLUNG, H., 260, 270
 THORNE, D. W., 217
 THURN, E. F. im, 84
 TOMASELLO, J. F., 204, 229
 TORROBA, M. A., 64, 162
 TORTORELLI, L. A., 172
 TRELLES, R. A., 59, 225
 TREWARTHA, G. T., 123
- URBAN, I., 54
 URBAN, O., 270
 UVAROV, B. P., 203, 205
- VALE, M. A. G., 270
 VALENCIA, J. A., 225
 VALENCIA, J. I., 159, 225, 229
 VEDANI, F. O., 182, 199, 200
 VELLARD, J., 88
 VERA, C. S., 191
 VERCESI, D. Rey, 191, 213-4
 VERDOORN, F., 227
 VERGARA, L. Correa, 70, 71, 72, 73, 151, 231
 VIGNATI, N. A., 271
 VILLAGRAN, F. P., 226
 VILLAGRAN PRADO, F., 226
 VILLAMEDIANA, J. J. R., 222
 VILLEGAS, A. T., 210
 VINALL, H. N., 226

- VINCENT, C., 211
VINCENT, N., Jr., 153, 213, 218, 219, 220

WARMING, E., 103, 226
WATKINS, J. M., 128, 156, 161, 162, 167, 169, 170,
173, 175, 212
WEAVER, J. E., 111, 114
WEBERBAUER, A., 75, 90, 226
WERNICKE, E., 185
WHITBECK, R. H., 33, 35
WHYTE, R. O., 271
WILLIAMS, F. E., 33, 35
WILLIAMS, L., 75

WILSON, C. M., 83, 88, 89
WILSON, J. P., 216
WITT, L. W., 240
WOODSON, R. E., 271
WORK, S. H., 213
WYLIE, Kathryn H., 80, 81, 92, 125, 126, 127,
238

YAHN, J. R., 35, 36

ZABALA, J., 181
ZUBIAUR, A. J., 162
ZUCKERMAN, H., 100 103

- Abelmoschus esculentus*, 165
Abrus precatorius, 181
Acacia, 65, 67, 68, 69, 87, 112, 122, 156, 165
 A. arabica, 165
 A. aroma, 165
 A. cavenia, 86, 165, 185
 A. cebil, 165
 A. cyanophylla, 191
 A. cymbispina, 165
 A. macracantha, 165, 185
 A. moniliformis, 69, 165
Acaena, 64
Aciachne pulvinata, 91
Acicarpa procumbens, 165
Acrocomia sclerocarpa, 166
 A. totai, 165, 166
Acuan virgata, 54
Adenocalymma alliaceum, 166, 182
Adesmia, 33, 39, 47, 54, 155, 166
 A. arborea, 155, 166
 A. bicolor, 39, 40, 41, 44, 49, 166
 A. brachycarpa, 155
 A. cinerea, 155, 166
 A. glaucescens, 155
 A. incana, 166, 186, 187
 A. landbecki, 155
 A. latifolia, 166
 A. latistipula, 155
 A. muricata, 6, 166
 A. punctata, 40, 43
 A. smithiae, 155
 A. trijuga, 108, 109
 A. viscida, 155
Aegopogon cenchroides, 79, 91, 112
Aeschynomene, 119, 154
 A. americana, 166
 A. falcata, 154
 A. marginata, 154
 A. sensitiva, 166
Aesculus hippocastanum, 166
Aextoxicon punctatum, 166
Agallostachys laciniosus, 101
Agave, 112, 113, 166, 195
Agropyron, 63, 98
 A. cristatum, 160
Agrostemma githago, 180, 182
Agrostis, 44, 62, 63, 79, 85, 163
 A. alba, 82
 A. breviculmis, 91
 A. haenkeana, 91
 A. magellanica, 62
 A. montevidensis, 43, 102
 A. perennans, 82, 85, 91
 A. pittieri, 91
 A. semiverticillata, 112
 A. stolonifera, 105
 A. trichoides, 91
 A. turrialbae, 91
Aira caryophylla, 39, 45
Albizia, 156
 A. lebbeke, 178
 A. lophantha, 166
Alchemilla, 82
 A. pinnata, 82, 87, 92, 229
Alopecurus, 63, 85
 A. aequalis, 85, 91
 A. antarcticus, 62, 63, 88
 A. pratensis, 76
Alternanthera philoxeroides, 166
Amaranthus, 68
 A. quitensis, 166, 209
 A. spinosus, 197
Ambrosia polystachya, 166
 A. tenuifolia, 182
Amicia andicola, 166
 A. fimbriata, 166
 A. medicaginea, 166
Ammi visnaga, 24, 57
Ammophila arenaria, 186, 187
Anarthrophyllum, 166
 A. rigidum, 166
Andira, 116
Andropogon, 24, 54, 58, 66, 69, 119, 124, 131, 134, 135
 A. annulatus, 135
 A. argenteus, 79
 A. bicornis, 120, 192
 A. caricosus, 135
 A. condensatus, 32, 37, 38, 39, 40, 41, 43, 44, 45, 47, 54, 58, 120, 199, 220
 A. consanguineus, 24, 43, 58, 109
 A. glaziovii, 102
 A. glomeratus, 112
 A. hirtiflorus, 120
 A. incanus, 54
 A. laguroides, 24, 27, 29, 61, 66
 A. lateralis, 37, 38, 43, 61, 66, 67
 A. lateralis var. *incanus*, 199
 A. leucopogon, 24
 A. paniculatus, 24
 A. pellitus, 37, 38, 44
 A. pertusus, 135
 A. saccharoides, 32, 38, 39, 40, 41, 42, 43, 44, 45, 59, 68, 91, 109, 112
 A. salzmanni, 66
 A. selloanus, 61, 120
 A. spathiflorus, 54
 A. tener, 220
 A. ternatus, 39, 40, 43, 44, 45, 199
 A. virginicus, 220
Anemone decapetala, 40
Anthemis cotula, 57, 209
Anthephora hermaphrodita, 122
Anthoxanthum odoratum, 82
Apium ammi, 166
 A. australe, 62

- Apodanthera biflora*, 166
Arachis hypogaea, 153, 225, 228
A. marginata, 44
A. prostrata, 115, 153
Araucaria angustifolia, 166
A. araucana, 166
Arecastrum romanzoffianum, 165, 166
Aristida, 37, 38, 39, 54, 58, 66, 67, 68, 112, 120, 121, 123, 199, 224
A. achalensis var. *elongata*, 86
A. adscensionis, 86, 91, 101, 109
A. circinalis, 66
A. cognata, 120
A. complanata, 54
A. mendocina, 109
A. murina, 39, 43, 45
A. pallens, 24, 29, 39, 40, 41, 44, 45, 54, 61, 66, 109
A. pittieri, 122
A. recurvata, 120
A. riparia, 120
A. setifolia, 102, 122
A. spegazzinii, 24, 87
A. subulata, 86, 87
A. uruguayensis, 66
A. venustula, 44, 45, 66
Aristotelia macqui, 166
Arrhenatherum elatius, 64, 82, 193
Artemisia verlotorum, 182
Arthrostylidium, 135
A. geminatum, 91
A. harmonicum, 263
Artocarpus communis, 166
A. incisa, 166
A. integrifolia, 166
Arundinella, 131, 135
A. hispida, 120
Arundo donax, 112, 185, 186, 191, 195
Aster squamatus, 41, 42, 166
Astragalus atuelii, 109
A. bergii, 109, 180, 181
A. chilensis, 228
A. unifolius, 180
Astrebla elymoides, 102
A. lappacea, 102
Atamisquea emarginata, 108
Atriplex, 104, 108
A. atacamensis, 166
A. coquimbana, 166
A. deserticola, 166
A. nummularia, 102, 104
A. repanda, 166
A. semibaccata, 102, 104, 167
Atropis magellunica, 62
A. ostentiana, 109
Attalea, 119
A. phalerata, 167
A. princeps, 167
Avellanitia, 167
Avena, 19, 112, 162
A. byzantina, 66, 146, 147, 148, 149
A. sativa, 83, 146, 147, 148, 197
A. sterilis, 38
Axonopus, 54, 58, 61, 66, 67, 121
A. anceps, 120, 123, 132
A. argentinus, 66
A. chrysodactylon, 120
A. compressus, 6, 39, 41, 42, 43, 44, 45, 59, 66, 67, 122, 124, 161, 188
A. fissifolius, 66
A. purpusii, 120, 124
A. scoparius, 127, 161
Baccharis, 54, 67
B. artemisioides, 167, 182
B. articulata, 181
B. conferta, 112
B. cordifolia, 6, 24, 39, 40, 41, 42, 43, 45, 66, 87, 180
B. genistelloides, 40, 54
B. gillestii, 87
B. magellanica, 164
B. racemosa, 167
B. subpingraea, 24
B. tenuifolia, 181
B. trimera, 6, 167
Bactris, 119, 121
Bambusa arundinacea, 191
B. guadua, see also *Guadua angustifolia*, 187
Bastardia viscosa, 167
Bauhinia, 101, 102
B. forficata, 102, 105, 167
Bellis perennis, 89
Beloperone squarrosa, 167
Benthamantha glabrescens, 167
Berberis buxifolia, 95
B. heterophylla, 95
Berroa, 41
B. gnaphalioides, 40, 41, 42, 167
Bombax, 182
Borreria leiophylla, 167
Bouteloua, 38, 58, 112
B. aristidoides, 86
B. curtipendula, 87
B. lophostachya, 68
B. megapota mica, 27, 40, 44, 61
B. multiseta, 40, 41
Bowdichia virgilioides, 105, 167
Brachiaria plantaginea, 220, 221
Bradburya, 167
B. sagittata, 167
Brassica, 57, 209
B. campestris, 73

- Bridgesia incisifolia*, 167
Briosa, 19, 24, 38, 39, 40, 45, 54, 58, 59
 B. erecta, 45
 B. minor, 19, 24, 39, 43, 44, 45
 B. stricta, 19, 86
 B. subaristata, 19, 66
 B. triloba, 24, 43, 44, 45, 109
Brodiaea tweediana, 182
 B. uniflora, 182
Bromelia laciniosa, 102, 167
Bromus, 19, 24, 38, 59, 62, 71, 85, 87, 99, 159
 B. arvensis, 194
 B. brevis, 24
 B. carinatus, 159
 B. catharticus : *B. unioides*, 19, 20, 24, 30, 31, 32, 38, 39, 41, 47, 48, 58, 64, 76, 82, 85, 88, 91, 96, 159, 181, 207, 220
 B. coloratus, 88
 B. erectus, 24, 43, 44
 B. hordeaceus, 19, 24
 B. inermis, 159
 B. macranthos, 63, 96
 B. mollis, 19, 24, 38, 64
 B. pitensis, 85, 91
 B. rigidus, 64
 B. secalinus, 64
 B. stamineus, 88
 B. unioides, see *B. catharticus*
Brosimum alicastrum, 167
Buchloe dactyloides, 112
Buchnera elongata, 45
Bulbostylis junciformis, 122
 B. juncoides, 39
Byrsonima, 119
 B. crassifolia, 7, 121
 B. verbascifolia, 132
Caesalpinia bracteosa, 105, 167, 177
 C. cacalaco, 112
 C. coriaria, 119
 C. corymbosa, 167
 C. ferrea, 102
 C. ferrea var. *cearensis*, 105, 167
 C. melanocarpa, 177
 C. praecox, 185
 C. pyramidalis, 102, 167
 C. rubicunda, 40
Cajanus, 156
 C. indicus, 153, 162, 223
Calamagrostis, 62, 75, 85, 88, 90
 C. bogotensis, 91
 C. coarctata, 91
 C. effusa, 91
 C. heterophylla, 91
 C. intermedia, 91
 C. longiaristata, 91
 C. montevidensis, 44
 C. pittieri, 91
 C. planifolia, 91
 C. polygama, 87
 C. rosea, 87
Calliandra, 66
 C. grandiflora, 112
Calopogonium, 155, 156, 167
 C. brachycarpum, 167
 C. mucunoides, 155, 162, 189
Calydorea campestris, 54
 C. nuda, 42
Canavalia, 156, 167
 C. ensiformis, 189
 C. gladiata, 156
 C. obtusifolia, 156
Canna, 67
Cannabis sativa, 167
Capparis scabrida, 167
Cardamine, 39
 C. chenopodiifolia, 45, 167
Carduus, 38, 57
 C. nutans, 210, 222
 C. pycnocephalus, 210, 222
Carex, 62, 66, 132
 C. bonariensis, 27, 87
Carica chilensis, 167, 177
Carthamus, 38, 43
 C. lanatus, 42
Cassia, 101, 119, 156
 C. acuta, 167
 C. aphylla, 96, 108, 109
 C. crassiramea, 168
 C. ferruginea, 105, 168
 C. fistula, 105, 168
 C. laevigata, 72, 178
 C. multijuga, 102, 168
 C. occidentalis, 197
 C. rotundifolia, 168
 C. siamea, 178
 C. tora, 105, 168, 197
Castanea vesca, 168
Casuarina equisetifolia, 168
 C. glauca, 168
 C. stricta, 168
Ceiba pentandra, 168
Celosia argenta, 168
Celtis brasiliensis, 168
 C. spinosa, 86, 109
Cenchrus, 68
 C. brownei, 122
 C. pauciflorus, 31, 109, 112
 C. pilosus, 120
Centaurea, 38
 C. calcitrapa, 40, 41, 209
 C. chilensis, 168
 C. melitensis, 57, 209
 C. repens, 209
 C. solstitialis, 209

- Centrosema*, 101, 156
C. pubescens, 155
C. virginianum, 168, 181
Cerastium glomeratum, 39, 44
C. nutans var. *argentina*, 87
Ceratonia siliqua, 168
Cercidium, 168
C. peninsulare, 168
Cereus, 7, 102, 168
C. eburneus, 168
C. gounellei, 168
C. jamacaru, 102, 168
C. stramineus, 168
C. undatus, 168, 177
C. variabilis, 101
Cestrum parqui, 86, 180
C. sendtnerianum, 182
Chaetothylax umbrosus, 168
Chamaecrista flexuosa, 132
Chaptalia, 54
Ch. exscapa, 6, 41, 42, 45
Ch. piloselloides, 41, 42, 45
Chenopodium hircinum, 209
Chevreulia stolonifera, 42
Chloris, 31, 40, 43, 67, 68, 69, 134
Ch. bahiensis, 39, 40, 42, 43, 44
Ch. canterai, 66, 68
Ch. ciliata, 27, 43, 44, 45, 61, 68, 109
Ch. distichophylla, 181, 229
Ch. gayana, 49, 65, 69, 82, 114, 115, 157, 158, 185, 213, 220, 223
Ch. polydactyla, 68, 122
Ch. radiata, 122
Ch. uliginosa, 40, 44
Chusquira, 108
Ch. erinacea, 108
Ch. hystrix, 108
Chusquea, 73
Ch. meyeriana, 55
Cicer arietinum, 206
Cinna poaeformis, 91
Cirsium lanceolatum, 40, 209
Cissampelos, 102, 168
Cissus sicyoides, 122, 168
Clematis hilarii, 180
Cocos nucifera, 168
Colliguaya odorifera, 168
Colocasia antiquorum, 168
Commelina nudiflora, 168
Condalia lineata, 86
C. microphylla, 108
Conium maculatum, 19, 57, 180
Conyza chilensis, 24, 38, 41
Copernicia cerifera, 168
C. tectorum, 119
Cordia boissieri, 168
C. decandra, 168
C. oncocalyx, 102, 105, 169, 177
C. rotundifolia, 169
Coriaria ruscifolia, 182
Cortaderia, 85
C. bifida, 91
C. dioica, see *C. selloana*, 20, 109
C. nitida, 91
C. rudiuscula, 86, 87
C. selloana : *C. dioica*,
Corynephorus canescens, 79
Cottea pappophoroides, 86
Cratylia mollis, 102, 169
Crescentia alata, 169
Cristaria hispida, 169
Crotalaria, 134, 156, 162, 197
C. juncea, 189
C. pumila, 112
C. retusa, 169
C. speciosa, 156
C. spectabilis, 156, 197
C. striata, 197
C. usaramoensis, 197
Cryptocarya peumus, 169
Cupania sapida, 169
Cuphea, 54
C. glutinosa, 40
Cupressus lambertiana, 186
Curatella americana, 132
Cuscuta, 209, 210
C. campestris, 210
C. epithymum, 209
C. indecora, 209, 210
C. indecora var. *longisepala*, 209
Cymbopogon, 131
C. rufus, see *Hyparrhenia rufa*, 120
C. schoenanthus, 189
Cynara, 38
C. cardunculus, 18, 40, 41, 207, 210, 222
Cynodon, 19, 163
C. dactylon, 30, 31, 33, 36, 39, 40, 41, 44, 57, 59, 76, 102, 109, 112, 161, 163, 188, 208, 209, 210
Cyperus, 38, 40, 41, 43, 44, 54, 67, 132
C. bourgaei, 112
C. giganteus, 68
C. monandrus, 109
C. reflexus, 27, 40, 41, 42, 44, 45
C. rotundus, 208
C. seslerioides, 112
C. vegetus, 40
Cytisus proliferus, 169
Dactylis glomerata, 62, 76, 79, 82, 92, 99, 112, 160, 173, 193, 207
Dactyloctenium aegyptium, 197

- Dalea citriodora*, 112
D. onobrychioides, 87
D. parryi, 169
D. polygonoides, 169
Danthonia, 37, 38
D. cirrata, 43, 44, 45, 199
D. montevidensis, 45
D. picta, 96
D. secundiflora, 91
Dasyllirion, 169
Datura ferox, 180
Daucus, 229
Deschampsia, 63, 229
D. flexuosa, 62
Desmanthus depressus, 169
D. virgatus, 24, 41
Desmodium, see also *Meibomia*, 66, 67, 68, 154, 169, 213, 233
D. adscendens, 89, 122, 162
D. affine, 154
D. asperum, 122
D. barbatum, 122, 153, 154
D. cuneatum, 154, 228
D. discolor, 153, 154, 162, 233
D. intortum, 89
D. rensoni, 154
D. sclerophyllum, 154
D. supinum, 154
D. umbrosum, 154
D. uncinatum, 154
Deyeuxia, 79
Dichondra repens, 27, 42
Dichromena, 132
Dicliptera jujuyensis, 169
D. tweediana, 169
Diectomis fastigiata, 120
Digitalis, 89
Digitaria fallens, 66
D. sanguinalis, 19, 30, 31, 32, 36, 38, 42, 54, 58, 59, 91, 101, 109, 122, 210
Diodia dasycephala, 169
Dioscorea batatas, 169
D. convolvulacea, 169
Diplachne dubia, 86
D. uninervia, 67, 68, 109
Diplothemium campestre, 169
Distichlis, 77, 112
D. humilis, 77
D. prostrata, 112
D. scoparia, 29, 31, 109
D. spicata, 27, 29, 30, 31, 109, 112
Dolichopsis paraguariensis, 169
Dolichos lablab var. *albiflorus*, 206
D. uncinatus, see *Teramnus uncinatus*
Echinochloa colona, 19, 36, 58, 59, 210
E. crus-galli, 36, 109, 112, 192
E. crus-pavonis, 67, 68
E. helodes, 68
E. polystachya, 120
Echium plantagineum, 19, 38, 169
E. violaceum, 36
Eclipta alba, 169
Eichhornia azurea, 169
Elephantopus angustifolius, 169
E. mollis, 169
E. scaber, 169
Eleusine, 24, 67
E. indica, 40, 105, 122
E. tristachya, 24, 26, 29, 30, 38, 40, 61, 109
Elymus, 63, 98
E. erianthus, 63
Elyonurus, 37, 38, 59, 66, 67, 68, 131
E. adustus, 120
E. candidus, 39, 40, 109
E. latiflorus, 54
E. tripsacoides, 87
Empetrum rubrum, 88, 164, 169
Encelia oblongifolia, 169
Encholirion spectabile, 102, 169
Enterolobium cyclocarpum, 169
Ephedra andina, 169
E. ochreate, 108
E. tweediana, 59, 165, 170
Epicampes, 112
Eragrostis, 24, 26, 39, 43, 44, 59, 66, 67, 68, 69, 112, 119, 134
E. articulata, 259
E. bahiensis, 39, 40, 43, 44, 45, 61
E. densissima, 79
E. flaccida, 66, 68
E. hypnoides, 59
E. interrupta, 66
E. longipila, 68
E. lugens, 24, 26, 27, 41, 61, 66, 68, 86, 87
E. maypurensis, 120, 121
E. megastachya, 109
E. neesii, 39, 40, 41, 42, 43, 44, 45
E. pilosa, 39, 40, 43, 44
E. reptans, 120
E. tef, 259
E. virescens, 42, 44, 86
E. viscosa, 122
Erianthus, 54, 67
E. angustifolius, 54
E. trinitii, 6, 40
Erigeron, 41
E. bonariensis, 42, 170, 182
E. chilensis, 170
E. montevidensis, 170
Eriochloa montevidensis, 59, 66, 68
E. punctata, 120
Eriosema, 121
E. lanceolatum, 132

- Erodium*, 19
E. cicutarium, 19, 38, 170
E. malacoides, 32, 58
Eryngium, 40
E. ebracteatum, 170
E. echinatum, 170
E. elegans, 170
E. nudicaule, 40, 41, 42, 44, 45, 170
E. paniculatum, 6, 170
E. sanguisorba, 170
Erythrina mulungu, 105, 170
Erythroxylon deciduum, 182
Escallonia arguta, 170
E. mutis, 170
Espeletia, 91
Eucalyptus, 51, 191
E. rostrata, 186
E. viminalis, 186
Euchlaena, 111
E. mexicana, 111
Eucryphia cordifolia, 170
Eupatorium, 67, 87, 112, 170
E. bartstifolium, 41
E. buniifolium, 170
E. laeve, 104
Euphorbia heterophylla, 182
E. lancifolia, 170
E. phosphorea, 104
E. portulacoides, 180
Euphrasia antarctica, 62
Euterpe stenophylla, 121
Evolvulus, 87

Fabiana viscosa, 170
Facelis retusa, 170
Festuca, 62, 63, 73, 75, 79, 85, 87, 88, 90, 96, 99, 163
F. acanthophylla, 73, 88
F. amplissima, 112³
F. australis, 6, 91
F. bromoides, 39
F. dissitiflora, 76, 220
F. elatior, 76
F. fuegiana : *Poa fuegiana*
F. gracillima, 98
F. hieronymi, 86, 87, 181
F. myuros, 91
F. orthophylla, 19
F. ovina, 79, 98, 99
F. pratensis, 76, 82
F. purpurascens, 88
F. tenella, 45
F. toluensis, 91
Ficus benjamina, 164, 170
F. padifolia, 170
Fimbristylis, 66
F. autumnalis, 44

Flourensia campestris, 86
F. riparia, 170, 185
Foeniculum vulgare, 19
Fourcroya, 112, 195
Frankenia, 170
Franseria cordifolia, 170

Galactia, 170
G. gracillima, 170
G. jussieuana, 121
G. marginalis, 44
Galega, 33
Galinsoga parviflora, 89, 170
Gentiana magellanica, 62
G. patagonica, 62
Geoffraea superba, 170
Geranium, 19, 91
G. albicans, 170
G. molle, 42, 64
G. pusillum, 43
Gerardia communis, 39
Gleditschia triacanthos, 170
Glycine, 156
G. hispida, 153, 156, 185, 197
Glycyrrhiza astragalina, 109, 171
Gnaphalium, 24, 27, 41
G. purpureum, 41, 43, 45
Gossypium, 171
Gouinia latifolia, 86
Gourliea decorticans, 87, 108, 185
G. spinosa, 171
Grimaldia hispidula, 132
Grindelia chilensis, 108
Guadua angustifolia, see also *Bambusa guadua*, 191
G. latifolia, 122
Guarea trichilioides, 171
Guazuma tomentosa, 171
G. ulmifolia, 122, 171
Gymnopogon foliosus, 121
G. mollis, 101, 104
Gynerium argenteum, 171
G. sagittatum, 195

Hackelochloa granularis, 105
Hamelia patens, 181
Hancornia speciosa, 130
Haplopappus parvifolius, 171
Haylockia pusilla, 171
Headsarum coronarium, 82, 155
Heimia salicifolia, 39, 67
Heleocharis, 62, 66
Helianthus annuus, 226
Helicostylis, 171
Heliotropium curassavicum, 27
Helleria, 85
H. fragilis, 91
Hemarthria altissima, 66, 67, 68
Hemicarpha, 132

- Herreria ophiopogonoides*, 171
Heteropogon, 131
Hibiscus sabbdariffa, 171
Hierochloë mexicana, 91
Hilaria cenchroides, 112
Holcus, 163
 H. lanatus, 64, 79, 82, 193
 H. mollis, 64
Holocalyx glaziovii, 181
Hordeum, 19, 24, 58, 59, 63, 98, 181, 229
 H. chilense, 88
 H. compressum, 26, 27
 H. hexastichum, 147
 H. murinum, 38
 H. murinum ssp. *leporinum*, 109
 H. pusillum, 27
 H. secalinum var. *pubiflorum*, 62
 H. stenostachys, 26, 109
 H. vulgare, 112
Hura polyandra, 171
Hydrocotyle, 39
 H. bonariensis, 39
Hymenachne amplexicaulis, 59
Hymenoclea monogyra, 171
Hymenoxys anthemoides, 181
Hypparrhenia hirta, 85, 91
 H. rufa, 102, 114, 115, 125, 127, 128, 161, 211, 220, 221, 223
Hypericum brathys, 91
 H. laricifolium, 91
Hypochoeris, 6
 H. radicata, 64
 H. setosa, 91
 H. tweediei, 42
Hyptis suaveolens, 124, 210
Hysterionica bakeri, 86

Imperata brasiliensis, 220
Indigofera, 115, 132, 153, 156, 171
 I. lespedezioides, 171
 I. pascuorum, 132, 171
 I. suffruticosa, 112
Inga affinis, 105, 171
 I. paterno, 171
Iodina rhombifolia, 86, 108
Ionidium bicolor, 54
Ipomoea arborescens var. *glabra*, 171, 177
 I. batatas, 171
 I. crassicaulis, 124
 I. glabra, 102, 171
 I. hederacea, 171
 I. pentaphylla, 171
 I. purpurea, 171
 I. sagittata, 171
 I. setifera, 171
 I. triloba, 171
Iulocroton montevidensis, 39

Juncus, 38, 39, 40, 41, 43, 44, 62
 J. acutus, 109
 J. chamissonis, 39, 41, 42
 J. imbricatus, 27, 40
 J. microcephalus, 42, 44, 45
Justicia campestris, 171
 J. echegarayi, 171

Kageneckia oblonga, 171
Koeleria phleoides, 19, 24
Kyllinga, 54
 K. monocephala, 120
 K. odorata, 120

Lantana, 102
 L. brasiliensis, 172
 L. camara, 172
 L. chamaedrifolia, 172
 L. mista, 172
 L. radula, 172
 L. undulata, 172
Larrea, 108
 L. cuneifolia, 108
 L. divaricata, 108
 L. nitida, 108
Lathyrus, 33, 54, 154, 155, 156, 225
 L. crassipes, 172
 L. grandiflorus, 89
 L. macropus, 87
 L. meridensis, 225
 L. nervosus, 109
 L. odoratus, 206
 L. paranensis, 172
 L. sativus, 155, 182
 L. silvestris, 59
 L. tingitanus, 155
 L. tomentosus, 187
Lecythis pisonis, 105, 172
Leersia hexandra, 67, 122
Lens esculenta, 206
Lepidium draba, 210
Lepidophyllum, 98, 164, 172
Leptocoryphium lanatum, 39, 42, 43, 44, 45, 120, 122
Lespedeza, 155
 L. sericea, 155
 L. stipulacea, 155
 L. striata, 155
Leucaena, 156
 L. glauca, 172
 L. trichodes, 172
Linum selaginoides, 43
Lippia lycioides, 86
 L. trifida, 108
Lithraea molleoides, 86, 172
 L. venenosa, 172
Llagunoa glandulosa, 172

- Lolium*, 19, 24, 32, 38, 58, 59, 79, 83, 162, 173, 181, 206, 207
L. italicum, see *L. multiflorum*
L. multiflorum : *L. italicum*, 6, 24, 29, 30, 38, 39, 41, 47, 48, 61, 76, 112, 148, 159, 160, 194, 207
L. multiflorum muticum, 39
L. perenne, 19, 76, 82, 97, 159, 160, 194, 207
L. subulatum, 64
L. temulentum, 36, 91, 180, 182, 207
Lomatia dentata, 172
L. ferruginea, 172
Lotus, 89
L. corniculatus, 156, 198
L. uliginosus, 72, 155, 194
Lupinus, 112, 154, 156, 200
L. albus, 156
L. alopecuroides, 91
L. jahnii, 91
L. luteus, 154
L. meridanus, 91
L. montanus, 156
L. multiflorus, 187
L. prostratus, 87
L. pubescens, 79
L. ramosissimus, 91
L. roseus, 91
L. rupestris, 79
L. tauri, 79
L. verbasciformis, 91
Luziola peruviana, 67
Lycurus alopecuroides, 86
Macrosiphonia, 54
Malvastrum acaule, 91
Malva viscus arboreus, 172
Manihot, 102, 182
M. aipi, 115
M. dulcis, 172
M. grahamii, 172
M. palmata, 172
M. utilissima, 172
Manisuris, 134
M. polystachya, 105
Margyricarpus, 41
M. setosus, 41, 42
Mariscus, 132
M. pycnostachyus, 112
Marlierea edulis, 172
Marrubium vulgare, 172
Mascagnia pubiflora, 182
Mauritia, 117, 119, 120, 121
M. flexuosa, 119, 121
M. minor, 7, 119, 121, 122, 124
Maytenus boaria, 165, 172
M. chilensis, 172
Medicago, 33, 38, 49, 210
M. arabica, 22, 38, 40, 41, 44, 89
M. arabica var. *maculata*, 47
M. arborea, 172
M. denticulata, 19, 49
M. hispida, 22, 38, 40, 41, 42, 43, 44, 156, 198
M. hispida var. *denticulata*, 6, 47, 58, 59, 82, 83, 89, 172
M. lupulina, 22, 97
M. maculata, 49
M. media, 142
M. minima, 22
M. sativa, 19, 21, 22, 30, 31, 76, 79, 81, 83, 85, 97, 99, 112, 124, 132, 134, 136, 141, 153, 196, 200, 215, 217, 223, 233
M. sativa var. *polia*, 142
M. sativa var. *peruviana*, 142
M. tivacata (sic.), 142
M. varia, 142
Meibomia, see also *Desmodium*, 101, 134, 172
M. adscendens, 134, 162, 172, 220
M. affinis, 101
M. aspera, 134
M. barbata, 115, 153, 220
M. discolor, 115, 134, 162, 172
M. pachyrrhiza, 134
M. platycarpa, 134, 172
M. spiralis, 101, 105, 172
M. uncinata, 82, 181
Melanthera aspera, 173
Melia azedarach, 173
Melica, 24, 39, 40, 58
M. argyrea, 109
M. macra, 27, 58, 108, 109
M. violacea, 43
Melilotus, 33, 99, 154, 217
M. alba, 82, 109, 154, 155, 156, 185, 191, 198
M. altissima, 155
M. indica, 22, 112, 154, 156, 198, 209
M. officinalis, 156, 198
M. parviflora, 191
Melinis, 68
M. minutiflora, 84, 85, 89, 102, 114, 115, 127, 160, 161, 196, 202, 211, 213, 220, 223, 233
Melocactus, 102, 173
Melochia tomentella, 173
Mesembryanthemum edule, 186
Mesosetum chaseae, 121
Miconia palmetorum, 121
Mikania micrantha, 173
Mimosa, 66, 119, 122, 156, 173
M. biuncifera, 112
M. cabrera, 119, 173
M. caesalpinifolia, 105, 173, 177
M. myriophylla, 181
M. vernicosa, 173
M. verrucosa, 105
Molinia, 163

- Montrichardia arborescens*, 121
Montea chilensis, 173
Morus alba, 173, 178
 M. multicaulis, 178
Mucuna, 115, 153
Muehlenbeckia chilensis, 173
Muehlenbergia, 112
 M. asperifolia, 109
 M. circinnata, 86
 M. erectifolia, 91
 M. fastigiata, 76, 77, 220
 M. gracillima, 87, 109
 M. ligularis, 75
 M. nardifolia, 87
 M. peruviana, 77
Mulinum spinosum, 182
Musa sapientum, 161, 173

Nardophyllum kingii, 96
Nardus, 163
Neocracca heterantha var. *minor*, 173
Neoglaziovia variegata, 102, 173, 177
Neosparton aphyllum, 108
Nierembergia hippomanica, 180
Nothofagus dombeyi, 173
Nothoscordum, 182
Nymphaea rudgeana, 173

Ocimum selloi, 173
Oenocarpus, 119
Oenothera indecora, 173
Oncostylis paradoxa, 122
Onobrychis sativa, 79
Opuntia, 102, 104, 112, 233
 O. dilleanii, 173
 O. ficus-indica, 164, 173
 O. inermis, 102, 161, 173
 O. mamillata, 173
 O. salmiana, 101
 O. tomentosa, 112
Ornithopus sativus, 82, 155, 194
Oryza, 229
 O. sativa, 229
Oxalis, 39, 40, 41, 43, 44, 54, 67, 86
 O. amara, 39, 42, 43
 O. articulata, 58
 O. bipartita, 6
 O. sellowiana, 42
 O. macachin, 6
Oxybaphus micranthus, 173
Oxypetalum solanoides, 180
Oyedeaea verbesinoides, 84

Palicourea longepedunculata, 181
 P. nicotianifolia, 181
Pamphalea heterophylla, 173
Panicum, 24, 42, 66, 67, 69, 84, 85, 112, 119, 121, 134, 135, 163
 P. aparine, 105
 P. barbinode, see *P. purpurascens*, 102
 P. bergii, 26, 43, 58, 66, 87
 P. bulbosum, 112
 P. decipiens, 42, 44
 P. dichotomiflorum, 67, 112
 P. elephantipes, 120
 P. equinum, see *P. purpurascens*,
 P. fasciculatum, 68, 122
 P. gouinii, 29
 P. grumosum, 59
 P. guadaloupense, see *P. purpurascens*,
 P. helobium, 67
 P. hians, 24, 26
 P. laxum, 40, 44, 59, 122
 P. maximum, 102, 114, 115, 122, 124, 125, 127, 128, 131, 134, 135, 161, 189, 211, 220, 223
 P. maximum var. *gongylodes*, 114, 134, 220
 P. micranthum, 120
 P. miliaceum, 109
 P. milioides, 24, 61, 66, 68
 P. molle ; see also *P. purpurascens*, 86, 122
 P. muticum ; see *P. purpurascens*
 P. numidianum ; see *P. purpurascens*
 P. paraguayense ; see *P. purpurascens*
 P. pictigluma ; see *P. purpurascens*
 P. pilcomayense, 68
 P. pilosum, 122
 P. prionitis, 58
 P. purpurascens (for synonyms see p. 128), 85, 86, 124, 125, 127, 128, 131, 135, 161, 196, 220, 223, 226
 P. racemosum, 186, 187, 192
 P. sabulorum, 66
 P. urvilleanum, 109, 185, 186, 187
 P. versicolor, 122
 P. verticillatum, 102
Pappophorum, 68
 P. elongatum, 86
 P. mucronulatum, 68, 87
Parkinsonia aculeata, 173
Parmentiera edulis, 174
Parthenium hysterophorus, 197
Paspalidium, 163
 P. paludivagum, 67
Paspalum, 24, 36, 54, 58, 59, 61, 66, 67, 69, 76, 79, 84, 85, 119, 121, 122, 124, 127, 128, 131, 134, 135, 163, 220
 P. acuminatum, 67
 P. alnum, 66, 67
 P. commune, 69
 P. conjugatum, 84, 91, 120, 122

- P. convexum*, 121
P. cromyorrhizon, 66
P. dilatatum, 19, 20, 24, 26, 29, 38, 39, 40, 41, 42, 43, 44, 60, 61, 67, 82, 161, 180, 181, 188
P. distichum, 19, 24, 26, 29, 30, 32, 36, 54, 59, 112
P. elongatum, 69, 87
P. fasciculatum, 120
P. fimbriatum, 121
P. furcatum, 54
P. gardnerianum, 120, 123
P. gayanum, 27
P. intermedium, 29, 68
P. lachneum, 132
P. larrañagai, see *P. urvillei*
P. leptostachyum, 120
P. lividum, 85
P. macrophyllum, 91
P. maculosum, 121
P. mandiocanum, 54, 189
P. maritimum, 101
P. millegranum, 121
P. nicorae, 66
P. notatum, 6, 24, 26, 38, 39, 40, 41, 42, 43, 44, 45, 54, 59, 60, 61, 66, 67, 69, 85, 122, 128, 135, 161, 188, 189, 220
P. platycaule, 54
P. plicatum, 37, 38, 39, 43, 44, 45, 61, 66, 69, 122, 135, 207
P. proliferum, 44, 207
P. pumilum, 66, 121, 122
P. quadrifarium, 19, 40, 67
P. repens, 59
P. rufum, 67
P. sanguinale, 54
P. trianae, 91
P. urvillei : *P. larrañagai*, 38, 40, 41, 44, 67, 69
P. vaginatum, 29, 30, 122
Pennisetum, 65, 68, 158
P. clandestinum, 82, 92, 114, 158, 196, 220, 223
P. peruvianum, 91
P. purpureum, 49, 82, 158, 185, 191, 196, 220, 223
Pernettya pumila, 164
Persea americana, 174
P. gratissima, 174
Petiveria alliacea, 174
Phalaris, 159
Ph. angusta, 45
Ph. bulbosa, 159
Ph. canariensis, 112
Ph. minor, 59, 159, 162, 231
Ph. tuberosa, 71, 159, 185, 194
Ph. tuberosa var. *stenoptera*, 159
Phaseolus, 121, 122, 156, 174, 185, 229
Ph. lunatus, 229
Ph. multiflorus, 206
Ph. panduratus, 221
Ph. vulgaris, 112, 206, 225, 229
Phleum alpinum, 62
Ph. pratense, 79, 99, 151
Phytolacca dioica, 18
Pilocereus setosus, 102, 174
Pinus halepensis, 186
Piptadenia, 122, 174
P. communis, 105, 174
P. moniliformis, 101, 174
Piptochaetium, 19, 24, 37, 38, 39, 40, 41, 42, 43, 58, 59, 199, 224
P. bicolor, 24
P. chaetaphorum, 86
P. hackelii, 27
P. montevidense, 24, 27, 39, 43, 45
P. napostaense, 86
P. ovatum, 27, 40, 44
P. panicoides, 6
P. stipoides, 39, 43, 44, 45
Pisum, 229
P. sativum, 206
Pithecolobium, 102, 174
P. auaremotemo, 104, 177
P. dulce, 174
P. guaricense, 119
P. ligustrinum, 122, 174
P. mexicanum, 174, 177
P. tortum, 119
Plantago, 39
P. lanceolata, 64, 209
P. maior, 64
P. media, 64
Platanus acerifolia, 174
Plazia argentea, 185, 186, 187
Pleonotoma variabilis, 181
Poa, 19, 24, 32, 38, 58, 59, 63, 73, 75, 85, 99, 112, 181, 232
P. alopecurus, 98
P. annua, 19, 38, 39, 44, 54, 59, 64, 76, 85, 91, 206, 220
P. bonariensis, 96
P. fuegiana, 73
P. lanigera, 27, 45, 192
P. lanuginosa, 187
P. ligularis, 109
P. patagonica, 98
P. pratensis, 19, 62, 64, 98
P. stuckertii, 87
P. trachyphylla, 85, 91
Podanthus mitiqui, 174
Polygala, 54
P. australis, 39, 43
P. linoides, 45
P. tenuis, 45
P. verticillata, 39

- Polygonum aviculare*, 209
P. bowenkampii, 174
P. persicarioides, 174
Polypogon, 63, 79, 112
P. elongatus, 26, 39, 91, 109
P. elongatus var. *muticus*, 27
P. interruptus, 91
P. monspeliensis, 109
Pontederia cordata, 174
Populus, 174, 185, 186
P. alba, 191
P. nigra, 174, 191
Poraqueiba sericea, 105
Portieria hygrometra, 174
Porophyllum ruderale, 174, 181
Portulaca, 68
P. oleracea, 174
Potentilla heterosepala, 91
Poterium sanguisorba, 194
Proboscidea altheifolia, 174
Prosopis, 68, 108, 112, 122, 174, 178, 185
P. alba, 108, 165, 174
P. alba form. *fruticosa*, 108
P. alpataco, 174
P. caldenia, 6, 7, 108; 109, 174, 185
P. campestris, 174
P. chilensis, 174
P. dulcis, 174
P. humilis, 108, 109
P. juliflora, 112, 164, 174, 178
P. nandubey, 56, 65
P. nigra, 86, 165, 175
P. panta, 165, 175
P. ruscifolia, 68, 175
P. striata, 108, 109
P. strombulifera, 96, 109
P. tamarugo, 175
Psamma arenaria; see *Ammophila arenaria*
Pseudocalymma elegans, 181
Psoralea glandulosa, 175
Ps. capitata, 182
Ps. florestana, 182
Ps. langsdorffiana, 182
Ps. leiocarpa, 182
Pterocaulon subvirgatum, 39
Puccinellia, 98
Pueraria, 156
P. thunbergiana, 115, 153, 188, 196
Quercus, 175
Q. grandis, 175
Q. pedunculata, 175
Ranunculus, 89
Raphanus raphanistrum, 209
Reimarochloa acuta, 122
Relbunium atherodes, 42
Rhynchosia, 33, 175
Rh. corylifolia, 109
Rh. lobata, 181
Rh. phaseoloides, 181
Rh. senna, 24, 39, 40, 43, 44, 109, 175
Rhynchospora luzuliformis, 39, 43, 45
Richardsonia stellaris, 41, 45
Ricinus communis, 175, 182
Robinia pseudo-acacia, 175
Rosmarinus officinalis, 175
Rottboellia, 59, 67
R. compressa, 39, 40, 44, 45
R. selloana, 6, 39, 40, 42, 43, 44, 66
Roupala, 119
R. complicata, 84
Ruellia, 102, 175
R. bahiensis, 175
Rumex, 38, 39
R. acetosella, 64
R. crispus, 209
R. pulcher, 73
Rustia bracteosa, 175
Saccharum officinarum, 115, 161
S. sinense, 161
S. spontaneum, 102
Salicornia, 175
Salix, 175
S. alba var. *caerulea*, 191
S. babylonica, 191
S. viminalis, 191
Salsola kali, 175, 209, 210
Salvia procurrens, 175
Samanea saman, 122, 175
Samolus spathulatus, 62
Sarothamnus scoparius, 175
Schedonnardus paniculatus, 27
Schinopsis lorentzii, 68, 165, 175
Schinus, 104
S. aroeira, 102, 175
S. latifolius, 175
S. polygamus, 108
Schismus arabicus, 64
S. barbatus, 64
Schizanthus pinnatus, 175
Schkuhria pinnata, 86
Scirpus, 62
S. maritimus, 109
S. riparius, 192
Scleria, 132
Scutellaria racemosa, 6
S. rumicifolia, 42
Sechium edule, 175
Secale cereale, 112, 147, 185, 207
Senecio bonariensis, 175
S. mendocinus, 108

- Serjania*, 181
 S. cuspidata, 181
Sesbania marginata, 181
 S. punicea, 181
Setaria, 38, 40, 42, 43, 44, 58, 61, 67, 68, 69, 112
 S. argentina, 86, 109
 S. caespitosa, 38, 40, 41, 42, 43, 44
 S. cordobensis, 68
 S. fiebrigii, 68, 86
 S. geniculata, 24, 26, 29, 30, 36, 39, 40, 43, 44, 45, 66, 68, 85, 91, 209, 223
 S. glauca, 112
 S. globulifera, 109
 S. gracilis, 39, 40, 43, 44
 S. mendocina, 109
 S. setosa, 223
 S. verticillata, 105
 S. viridis, 39, 112
Sida intermedia, 45
 S. leprosa, 27
 S. rhombifolia, 122, 175
Silene gallica, 89
Silybum, 38
 S. marianum, 18, 38, 175, 207, 210, 222
Simmondsia californica, 175
Sisyrinchium, 39, 86
 S. cuspidatum, 73
 S. platense, 175
Soaresia nitida, 105, 176
Solanum auriculatum, 176
 S. bullatum, 176
 S. capsicastrum, 181
 S. cernuum, 176
 S. commersonii, 176
 S. elaeagnifolium, 181
 S. glaucum, 181
 S. lycopersicum, 226
 S. pseudocapsicum, 181
 S. sisymbriifolium, 181
 S. verbascifolium, 176
Solidago chilensis, 86, 176
 S. microglossa, 39
Soliva sessilis, 41, 176
Sonchus asper, 176
Sorghastrum agrostoides, 61
Sorghum, 65, 68, 157
 S. alnum, 157
 S. caffrorum, 66, 68, 207
 S. dochna var. *technicum*, 157
 S. halepense, 36, 180, 208, 209
 S. sudanense, 29, 32, 49, 66, 76, 157, 179, 191, 207
 S. vulgare var. *saccharatum*, 157
Spartina, 181, 206
 S. brasiliensis, 206
 S. ciliata, 187, 192
 S. montevidensis, 206
Spartium junceum, 112, 176, 195
Specularia perfoliata, 176
Spergula levis, 41
Spergularia, 27
Sphacele lindleyi, 176
Spigelia humboldtiana, 176
Spilanthes americana, 82
 S. arnicoides, 40
 S. decumbens, 6
Sporobolus, 38, 39, 41, 42, 112, 119, 134
 S. aeneus, 66
 S. argutus, 30
 S. berterianus, see *S. poiiretii*
 S. brasiliensis, 91
 S. cubensis, 120, 132
 S. fastigiatus, 77
 S. indicus, 26, 112, 120, 122
 S. plumbeus, 112
 S. poiiretii : *S. berterianus*, 24, 27, 29, 38, 39, 40, 41, 42, 43, 44, 45, 61, 66, 82, 91, 181, 207
 S. pyramidalis, 27, 68
 S. rigens, 109, 187
 S. subinclusus, 109
 S. tenacissimus, 43, 79, 120
Stachys arvensis, 176
Stellaria media, 38
Stenachaenium campestre, 45
Stenocalyx dysentericus, 176
Stenodrepanum bergii, 176
Stenotaphrum americanum, 39, 41, 42, 43, 44, 45
 S. secundatum, 29, 188, 190
Stipa, 24, 27, 32, 36, 37, 38, 39, 40, 41, 42, 43, 44, 58, 59, 63, 85, 87, 88, 98, 112, 181, 185, 186, 224
 S. argentea, 98
 S. bomani, 180, 181
 S. brachychaeta, 27, 58
 S. charruana, 6, 38, 59
 S. cordobensis, 86
 S. dusenii, 108
 S. frigida, 73
 S. hirtiflora, 98
 S. humilis, 96, 98
 S. hyalina, 19, 24, 26, 27, 29, 30, 38, 40, 41, 44, 59, 61
 S. hypogona, 108, 109
 S. ichu, 19, 75, 76, 85, 86, 87, 91, 109, 213
 S. kurtzii, 98
 S. leptostachya, 86, 180
 S. mendocina, 212
 S. mexicana, 85, 91
 S. mucronata, 85, 91, 98
 S. neaei, 96
 S. neesiana, 19, 24, 27, 38, 39, 41, 43, 54, 59, 66
 S. pampagrandensis, 86
 S. papposa, 24, 27, 29, 30, 41, 42, 43, 61, 66
 S. patagonica, 96, 98
 S. pogonanthera, 96

- S. polyclada*, 86
S. saltensis, 181
S. tenuis, 98
S. tenuissima, 86, 109, 212
S. trichotoma, 19
Stizolobium, 153
 S. deeringianum, 162, 185, 189, 197
 S. hassjoo, 185
Stryphnodendron obovatum, 105
Stylosanthes, 66, 134, 154, 176
 S. guianensis, 54, 102, 154
 S. guianensis var. *subviscosus*, 154
 S. montevidensis, 176
Syagrus oleracea, 176
 S. picrophylla, 176
Symphytum asperrimum, 161
 S. officinale, 161

Tagetes minuta, 176
Talguea costata, 176
Talinum, 68
Tamarix gallica, 191
Tanaecium nocturnum, 181
Taraxacum, 89
 T. officinale, 64, 210
Telanthera polygonoides, 176
Tephrosia, 156
 T. cinerea, 132
Teramnus uncinatus : *Dolichos uncinatus*, 101, 176
 T. volubilis, 176
Teucrium depressum, 176
 T. laevigatum, 176
Thalia, 67
 T. geniculata, 176
Thiloa glaucocarpa, 176
Thlaspi arvense, 209
Thrasya, 84
Tipuana tipu, 176
Trachypogon, 120, 121, 131, 132
 T. ligularis, 91
 T. montufari, 37, 38, 43, 45, 91, 120
 T. plumosus, 120, 122, 123, 132
 T. polymorphus, 54
 T. vestitus, 120
Traganum scariosum, 176
Trema micranthum, 176
Trevoa trinervia, 176
Trichachne, 68, 69
 T. friesii, 86
 T. insularis, 69, 109
 T. penicilligera, 68, 69, 86
Trichloris, 68, 69
 T. mendocina, 108, 109
 T. pluriflora, 86
Tricholaena repens, 84, 91
 T. rosea, 102
Tridens brasiliensis, 19, 66

Trifolium, 33, 49, 54, 59, 71, 112, 150, 163, 200, 203, 225
 T. alexandrinum, 82, 152
 T. amabile, 79, 112, 153
 T. argentinense, 153
 T. campestre, 153
 T. carolinianum, 156, 198
 T. dubium, 153
 T. filiforme, 153
 T. fragiferum, 152
 T. hybridum, 22, 81, 99, 152
 T. incarnatum, 81, 99, 152, 194
 T. involucratum, 112
 T. matthewsi, 87
 T. polymorphum, 6, 39, 41, 42, 43, 44, 47, 153, 177, 187
 T. pratense, 22, 79, 81, 83, 150, 151, 152, 156, 198
 T. repens, 19, 22, 64, 79, 81, 83, 89, 99, 112, 150, 156, 194, 198, 223
 T. repens var. *giganteum*, 150
 T. repens f. *riparia*, 150
 T. repens var. *sylvestre*, 150
 T. spadicum, 153
 T. strepens, 153
 T. subterraneum, 152
Triglochin palustre, 62
Tripogon spicatus, 61
Tripsacum, 111, 161
 T. dactyloides, 111
 T. laxum, 83
Trisetum, 85, 229
 T. deyeuxioides, 85, 91
 T. subspicatum, 96
Tristachya chrysothrix, 134
 T. leiostachya, 134
Trithrinx campestris, 56, 213
Triticum aestivum, 85, 91
 T. vulgare, 112
Trixis hieracioides, 177
Trophis americana, 122, 177
Typha domingensis, 192

Ugni molinae, 88, 177

Vasconcellea chilensis, 177
Verbena, 6, 43, 66
 V. chamaedryfolia, 26, 41
 V. connatifoliatea, 108
 V. erinoides, 177
 V. gracilis, 45
 V. litoralis, 177
 V. tridens, 96, 164, 177
Vernonia, 40, 67, 112
 V. flexuosa, 40
Veronica, 89
 V. arvensis, 177

- V. officinalis*, 64
V. peregrina ssp. *xalapensis*, 177
Vetiveria zizanioides, 189
Vicia, 33, 154, 162, 229
 V. benghalensis, 153, 154, 159, 162
 V. faba, 185
 V. faba f. *megalosperma*, 206
 V. graminea, 44
 V. linearifolia, 40, 43, 177
 V. nana, 24
 V. nigricans, 154
 V. patagonica, 88
 V. sativa, 89, 153, 154, 162, 182, 217
 V. villosa, 36, 82, 89, 92, 153, 154, 185, 217
Vigna, 156
 V. luteola, 122
 V. sinensis, 115, 153, 162, 185, 206
 V. unguiculata, 156
 V. vexillata, 122, 156, 198
Viguiera mandonii, 177
Vouacapoua anthelmintica, 177
Wedelia glauca, 180, 181, 209
Xanthium, 67
 X. cavanillesii, 180, 209
 X. spinosum, 57, 209
 X. strumarium, 209
Yucca, 112
Zea mays, 83, 162, 197, 232
Zinnia peruviana, 86
 Z. uniflora, 68
Zizyphus joazeiro, 105, 177
 Z. mistol, 177
Zornia, 101
 Z. diphylla, 54, 154, 177
 Z. gracilis, 177
 Z. latifolia, 177

